EXPEDITIONSPROGRAMM NR. 92

RV POLARSTERN

ANT-XXIX/8
09 November 2013 – 16 December 2013
Cape Town – Cape Town

ANT-XXIX/9
19 December 2013 - 05 March 2014
Cape Town - Cape Town

ANT-XXIX/10
08 March 2014 - 13 April 2014
Cape Town - Bremerhaven

Coordinator

Rainer Knust

Chief Scientists

ANT-XXIX/8: Vera Schlindwein
ANT-XXIX/9: Rainer Knust
ANT-XXIX/10: Hartwig Deneke

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1. EXPEDITION ANT-XXIX/8

1.1 ÜBERBLICK ÜBERBLICK UND FAHRTVERLAUF

V. Schlindwein (AWI)

Am 9. November 2013 wird das Forschungsschiff *Polarstern* von Kapstadt zur Forschungsreise ANT-XXIX/8 auslaufen, die der Erkundung des Südwestindischen Rückens gewidmet ist. Zunächst wird der Kurs nach Süd-Südwest führen ins Messgebiet bei ca. 13° E und 52,5°S. In dieser Region werden wir uns circa 26 Tage aufhalten. Nach Ende der Messzeit werden wir direkt nach Kapstadt zurückkehren und dort am 16. Dezember 2013 einlaufen. Die Fahrtroute ist in Abbildung 1.1 dargestellt.

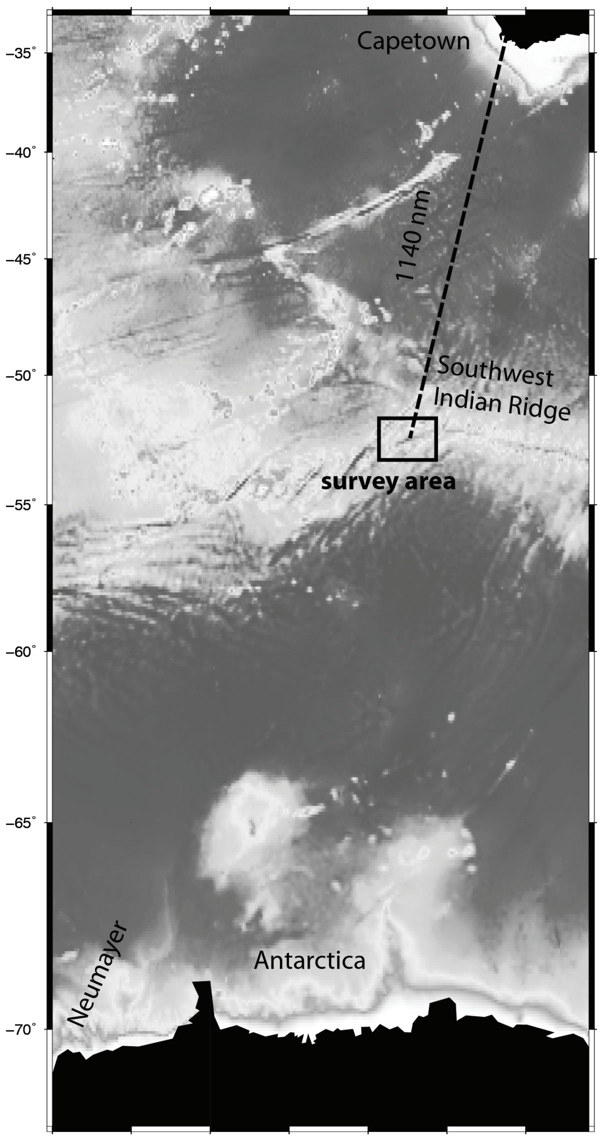

Fig. 1.1 Lage des Messgebiets und geplante Fahrtroute. Alle Arbeiten finden am Südwestindischen Rücken bei ca. 52° 15'S und 13° 30'E statt.

Fig. 1.1 Position of survey area and planned itinerary.

All station work will be conducted at the Southwest Indian Ridge near 52° 15'S and 13° 30'E.

Der Südwestindische Rücken (SWIR) gehört mit Spreizungsraten von <15 mm/y zu den sich am langsamsten öffnenden mittelozeanischen Rücken der Welt, zu den sogenannten ultralangsamen Rücken. Von den ultralangsamen Rücken sind der SWIR und das arktische Rückensystem wegen ihrer schlechten Erreichbarkeit bislang wenig erforscht. Alle bisherigen Erkenntnisse zeigen jedoch, dass diese Rücken nicht gängigen Modellen für Ozeanbodenspreizung entsprechen. So finden sich an den ultralangsamen Rücken trotz geringer Produktion von Schmelzen und einer sehr kalten Lithosphäre unerwartet viele hydrothermale Anomalien in der Wassersäule, die auf aktive Vents hindeuten. Magma tritt an ultralangsamen Rücken an einzelnen Vulkanzentren aus, während in den dazwischen liegenden Bereichen Mantelgestein am Meeresboden ansteht. Unsere Reise steuert eine solche Magma-arme Region an, das sogenannte Oblique Supersegment des SWIR, wo hydrothermale Anomalien in der Wassersäule bekannt sind. In einem interdisziplinären Ansatz wollen wir die Struktur der Erdkruste erkunden, die aktiven tektonischen Prozesse anhand der Erdbebenaktivität beobachten und den thermischen Zustand der Lithosphäre messen. Wir werden systematisch nach hydrothermalen Anomalien in der Wassersäule suchen, deren chemische und physikalische Eigenschaften bestimmen und versuchen, die Quelle dieser Anomalien am Meeresboden zu orten. Wir wollen die biologischen Gemeinschaften erkunden, die mit den hydrothermalen Quellen verbunden sind, die Zusammensetzung der chemischen Energie an den Quellen erforschen, und unser Wissen über Tiefseefauna und mikrobielle Diversität sowie chemosynthetischer Produktivität dieser entlegenen Regionen verbessern.

Während wir uns dem Messgebiet nähern, werden wir erste Messungen des Wärmestroms entlang eines Profils in Spreizungsrichtung durchführen. Wir benötigen Messungen des Wärmestroms in unterschiedlich alter Erdkruste bis hin zur jüngsten Erdkruste an der Rückenachse. Sobald wir das Messgebiet erreicht haben, werden Airgun Profile über die während ANT-XXIX/2 ausgebrachten Ozeanbodenseismometer (OBS) geschossen. Die Geräte liegen in ca. 15 km Abstand am Meeresboden und haben nun ein Jahr lang Erdbeben aufgezeichnet. Die Airgun Profile werden ca. 3 Tage in Anspruch nehmen und geben uns Aufschluss über die Struktur der Erdkruste. Danach werden die OBS einzeln ausgelöst und geborgen. Diese Arbeiten werden vorrangig bei gutem Wetter durchgeführt und benötigen ca. 2 Tage.

Danach, bzw. auch dazwischen bei weniger günstigen Wetterbedingungen wird die systematische Suche nach hydrothermalen Fluidaustritten und deren Quellen mit Hilfe der CTD-Sonde, Wasserproben und speziellen Plume-Recordern (MAPR) beginnen. Sämtliches weiteres wissenschaftliches Beprobungsprogramm wird ad hoc auf Basis der CTD Ergebnisse und der Wettergegebenheiten geplant und durchgeführt werden. Da das Messgebiet sehr kleinräumig ist (ca. 50 km Ausdehnung) können wir ohne große Transitzeiten effektiv zwischen Messgeräten und den Aufgaben der verschiedenen Arbeitsgruppen an Bord wechseln. Zur Erkundung und Beprobung des Meeresbodens und seiner biologischen Gemeinschaften werden wir unter anderem die Ozeanbodenbeobachtungsplattform OFOS, TV-gesteuerte Greifer und -Multicorer, Schwerelote und Gesteinssammler einsetzen. Außerdem werden wir uns detaillierte Kenntnisse über die Bathymetrie und Sedimentbedeckung des Meeresbodens verschaffen.

Wir hoffen von dieser Reise eine Vielfalt neuer Daten über einen außergewöhnlichen mittelozeanischen Rücken, seine Struktur, die aktiven geologischen Prozesse und seine biologischen Lebensgemeinschaften mitbringen zu können.

SUMMARY AND ITINERARY

On November 9th, 2013, *Polarstern* will depart from Cape Town for research cruise ANT-XXIX/8 exploring the Southwest Indian Ridge. We will leave Cape Town in south-southwesterly direction towards our survey area at 13°E and 52.5°S. In this area we will stay for 26 days. After the end of the survey time, we will return directly to South Africa, arriving in Cape Town on December 16th, 2013. The itinerary is shown in Fig. 1.1.

With spreading rates below 15 mm/y, the Southwest Indian Ridge (SWIR) belongs to the slowest spreading mid-ocean ridges on earth, which are called ultraslow spreading ridges. This class of spreading ridges is poorly explored, because the main ultraslow spreading ridges, the SWIR and the Arctic mid-ocean ridge system, are situated in remote areas that are logistically difficult to access. Our present knowledge about ultraslow spreading ridges indicates that common theories for ocean floor spreading are not applicable to the slowest end members of mid-ocean ridges. Despite a limited production of melts and a cold lithosphere, ultraslow spreading ridges show an unexpected abundance of hydrothermal anomalies in the water column that may indicate active venting at the seafloor. At ultraslow spreading ridges, magma is focussed towards widely spaced volcanic centres whereas mantle rocks may cover the seafloor in the magma-starved areas in between. ANT-XXIX/8 will investigate such a magma-starved area, the so-called Oblique Supersegment of the SWIR, where hydrothermal anomalies in the water column had been discovered earlier. The interdisciplinary science party of ANT-XXIX/8 will explore the structure of the earth's crust, observe the earthquake activity and hence the active tectonic processes and measure the thermal state of the lithosphere. We will search systematically for hydrothermal plumes in the water column, determine their chemical and physical properties and try to locate their sources at the seafloor. We will explore the biological communities that inhabit the hydrothermal vents and their surroundings, investigate their potential energy sources provided by the vents, and we will expand our knowledge about the deep-sea fauna, microbial diversity and chemosynthetic productivity in this remote region.

While approaching the survey area, we will perform first heat flow measurements along a profile parallel to the spreading direction. We need heat flow measurements in crust of different geological ages including the youngest crust at the axis of the mid-ocean ridge.

As soon as we have reached the survey area, we will shoot airgun profiles across the 10 ocean bottom seismometers (OBS) that were deployed during ANT-XXIX/2. The instruments reside on the seafloor in distances of about 15 km and have recorded earthquakes since their deployment one year ago. The airgun profiling will take about 3 days and will give us information about the structure of the earth's crust. After that, the OBS will be released and recovered one by one. OBS recovery will be preferentially done in good weather and will take about 2 days.

After that, or during periods of less favourable weather conditions, we will start to systematically search for hydrothermal plumes and vents using the CTD/rosette system and special plume recorders (MAPR). All further scientific sampling programme will be planned and performed ad hoc depending on the CTD results and on weather conditions. As the survey area is spatially very confined (less than 50 km extent), we can effectively swap between survey instruments and the research tasks of the different working groups without long transit times. To explore and sample the seafloor and its biological communities, we will use the ocean floor observing system OFOS, video grab and coring devices, gravity corer and rock dredges. In addition, we will gather detailed information on the bathymetry and sediment cover of the sea floor.

We hope to return from this cruise with an ampleness of new data on an exceptional spreading ridge, its structure, active geological processes and its biological communities.

1.2 SEISMICITY AND THERMAL STATE OF THE ULTRASLOW SPREADING OBLIQUE SUPERSEGMENT OF THE SWIR

1.2.1 Seismology

V. Schlindwein, S. Coers, K. Hochmuth, H. Kirk, N. Lensch, F. Schmid, J. Scholz (AWI)

Objectives

Ocean basins are formed by seafloor spreading at active mid-ocean ridges. Mantle material is upwelling under the ridges and melts to produce magma, which erupts onto the sea floor and crystallises at depth to produce new oceanic crust. Crustal generation and plate separation rate keep pace over a wide range of spreading rates and produce oceanic crust with a uniform thickness of about 7 km. Yet, models predict that at spreading rates below about 20 mm/y, the mantle loses heat by conduction and only small amounts of melt are produced at large depths (Bown & White, 1994). Consequently, magmatism and crustal thickness should decrease with decreasing spreading rate. Volcanic eruptions should be unlikely at ultraslow-spreading ridges (< 20 mm/y). Until recently, very little data from ultraslow-spreading ridges were available to verify this theory because these ridges are located in remote ocean basins like the ice covered Arctic Ocean and the stormy Southern Ocean.

Contradicting the common theory, ultraslow-spreading ridges are divided into segments with pronounced volcanism and segments lacking any signs of mantle melting, their distribution being independent of the spreading rate (Michael *et al.,* 2003). New models are therefore necessary to describe the processes of crustal generation at ultraslow-spreading ridges.

Microearthquakes image the active tectonic and magmatic processes at mid-ocean ridges and therefore help to understand crustal generation. At ultraslow-spreading ridges the microseismicity is hardly explored. The junior research group "MOVE" at AWI studies the seismicity of ultraslow-spreading ridges in various projects (e.g. Korger & Schlindwein, 2012; Läderach *et al.,* 2011; Läderach *et al.,* 2012; Schlindwein, 2012; Schlindwein *et al.,* 2013). Up to now, we have mainly studied the Arctic ridge system, which is tectonically less complicated than the Southwest-Indian ridge (SWIR). In the Arctic, we used land seismometers installed on drifting ice floes to record earthquakes as small as magnitude 1 or below (Läderach & Schlindwein, 2011). The drawback of this method is that we could only acquire data for time periods of 2 - 3 weeks, which is very little to record statistically representative numbers of earthquakes.

We therefore focus our current research activities on the SWIR, which is located halfway between Africa and Antarctica. The open waters allow using Ocean Bottom Seismometers (OBS), which are deployed on the seafloor and can remain there for a period of about one year and thus record sufficiently high numbers of small earthquakes. Up to now, no *in-situ* records of the seismicity of the SWIR exist, because the recovery of the OBS in stormy waters is risky. In addition, the SWIR is not an ideal candidate for studying ridge processes as it is tectonically complicated, being oriented obliquely to the direction of plate motion. Especially at the eastern part of the SWIR, magmatic and amagmatic crustal production are unstable in time and space such that a complicated structure results.

In our current project, we want to compare the seismicity and structure of a site of magmatic crustal production and a site of amagmatic crustal production. For the magmatic site, we chose a recently active submarine volcano at the eastern SWIR. It has been instrumented during a cruise with *Marion Dufresne* in September and October 2012 with 8 OBS, which will be retrieved at the same time as ANT-XXIX/8 by other members of MOVE on board of *Meteor*. During the current *Polarstern* expedition, we want to explore the spreading processes of an amagmatic ridge section. In addition, hydrothermal discharge into the water column has been discovered in this area (Bach *et al.,* 2002). Microearthquakes are able to track circulating fluids and can therefore help to understand amagmatic hydrothermal systems. We have instrumented the survey site during ANT-XXIX/2 one year ago (Figure 1.2.1 and Table 1.2.1). Our OBS are distributed in a rough triangle of about 70 km side length spanning the rift valley and its flanks in an area of a suspected hydrothermal vent. ANT-XXIX/8 is dedicated to the exploration of this hydrothermal system and will remain in the survey area for many days, so that we will have good chances to recover the OBS in favourable weather conditions. By then the seismometers will have stored several thousands of small earthquakes in their internal data logger, the location of which can tell us for example about the maximal depth of faulting and thus the thermal structure of the lithosphere.

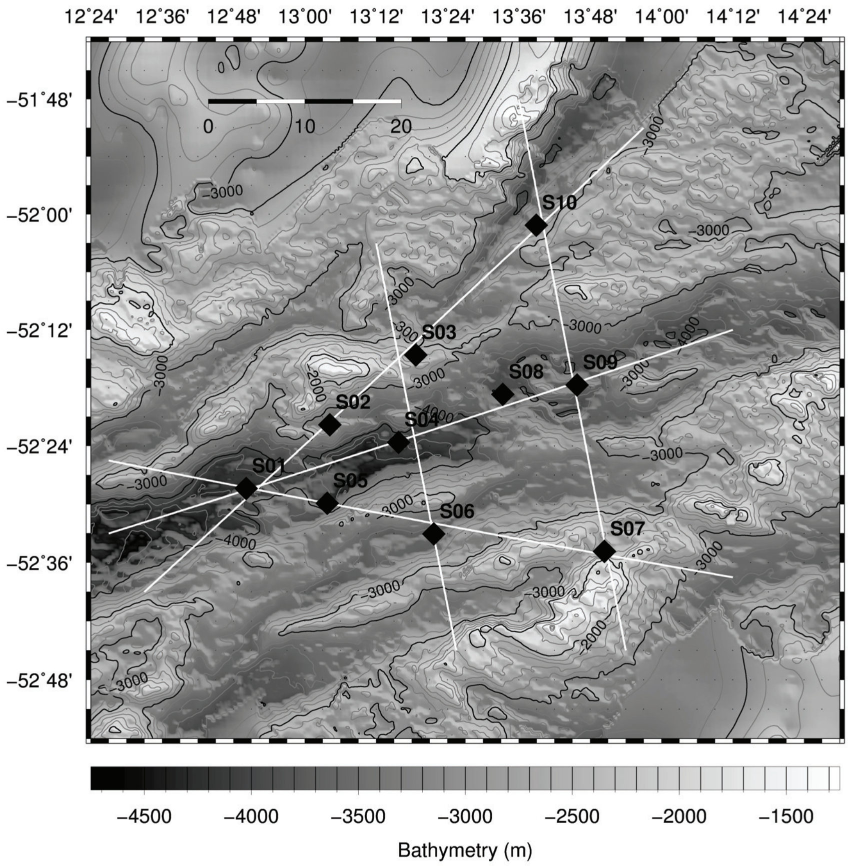

Fig. 1.2.1: Survey area at the Oblique Supersegment of the SWIR. Black diamonds indicate position of OBS S01-S10. White lines are planned airgun profiles. Distance scale is in kilometer. Bathymetry data as published in Dick et al. (2003)

Work at sea

During the transit from Cape Town, we will assemble four airguns. When we arrive in the survey area, we will shoot short refraction seismic lines across the locations of our OBS (Figure 1.2.1), which by then will have recorded earthquakes for 12 months. The airgun profiles are necessary to determine the seismic velocity structure of the crust in the survey area and to accurately determine the position of the OBS at the seafloor. Both parameters are needed to obtain high quality hypocentre locations of the recorded earthquakes. This is a prerequisite for any meaningful geological analysis of the seismicity.

After the airgun profiles have been completed, the airgun launch-way will be de-installed to create space on deck. We will start to recover the OBS in favourable weather conditions with an ocean swell less than about 5 m. The OBS will be acoustically released with a transducer that will be lowered on a cable from the aft deck just below the sea surface. Once detached from their anchor weight, the OBS take about 40 - 60 min to rise from the seafloor. Flash lights, radio beacons and ARGOS transmitter will help to locate the OBS. The OBS will be hooked and heaved on board by crane. Once on board, the internal clock has to be synchronized before data can be downloaded and archived. The OBS further carry a temperature sensor and a biological colonization experiment, which need to be taken care of. The OBS will then be disassembled and stored in their transport container.

Preliminary (expected) results

We expect to record several thousands of earthquakes of small magnitudes. However, the data will only be available in continuous raw format after recovery. We expect that we can convert the data on board and do a preliminary quality check and get an overview of data return. Extraction and location of earthquakes from the data set requires many processing steps that will take several months and cannot be performed during the cruise. Therefore, the present cruise will not yield any data for immediate geological interpretation.

Data management

Our seismic data will be archived in a common data repository for all data acquired with the OBSs of the DEPAS instrument pool. This archive is currently being developed and implemented at AWI. After 3 years of restricted access, the data will be made publicly available through the GEOFON seismic data request system.

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Tab. 1.2.1.: Deployment sites and times of all 10 OBS. Stations with „T“ in their name carry a temperature sensor. Stations marked with „A“ are equipped with an ARGOS transmitter

Deploy-ment Nr	Deployment Longitude °E	Deployment Latitude °S	Water depth (m)	Station number	Deployment Date	Deploy-ment Time (UTC)
1	13.6490	52.0190	3422	S10-00	05.12.2012	09:58
2	13.7636	52.2950	3818	S09-A0	05.12.2012	13:20
3	13.5554	52.3110	3974	S08-0T	05.12.2012	14:54
4	13.8400	52.5806	2708	S07-00	05.12.2012	16:55
5	13.3618	52.5508	3695	S06-AT	05.12.2012	19:30
6	13.2628	52.3936	4395	S04-AT	05.12.2012	21:00
7	13.3112	52.2433	2977	S03-AT	05.12.2012	22:27
8	13.0703	52.3636	3310	S02-00	06.12.2012	00:10
9	13.0627	52.4982	4227	S05-AT	06.12.2012	01:20
10	12.8354	52.4729	4426	S01-00	06.12.2012	02:42

1.2.2 Heat flow

N. Kaul, B. Heesemann, D. Thiel (FB5)

Objectives

Ultraslow spreading ridges are supposed to be „cold“ ridges with minor amounts of melt. Observations of concentrated magmatic activity indicate that there must be a transport of magma and energy in direction of the magmatic centers (Bown & White, 1994, Michael et al., 2003, Standish et al., 2008).

The depth of hypocenters at ultraslow ridges varies between 8 and 25 km and is used as a proxy for the Lithosphere-Asthenosphere boundary (LAB). This boundary is assumed to correlate with the 600°C isotherm (Bohnenstiehl & Dziak, 2009). The strong undulation of the LAB should be detectable through heat flow determinations.

Based on petrological models for the Southwest Indian Ridge (SWIR) (Standish et al., 2008) we assume that the LAB has a similar topography as found at Knipovich Ridge (Schlindwein et al., 2013). Combined seismological and heat flow research should help to proof the hypothesis.

Three profiles of heat flow determinations are planned, along the ridge and across on selected locations, representative for elevated and starved magmatic areas.

Work at sea

Heat flow determinations are planned at 20 locations, using the Bremen heat flow probe. This instrument can penetrate up to 6 m into the seafloor and take temperature measurements at 21 sensors. It is robust to cope with poorly sedimented areas. Temperature gradient and thermal conductivity are going to be calculated on board.

Additionally, so called MTLs, miniaturized temperature data logger will be attached to OFOS and other equipment, towed near the bottom. This gives additional information in the search for hydrothermal plumes.

Expected results

In general, we expect to see surface heat flow varying along axis to reflect the undulating LAB. Two NNE-SSW transects on bathymetric highs and lows are to be probed plus one profile along the ridge axis. Transits to and from Cape Town can be used to extend the profiles to the north, meaning to greater crustal age. Bathymetry data have to be exploited to find correction for topographic effects.

Data management

Original data are going to be stored in the PANGAEA data base. Results are stored as soon as they are available. They are going to be published in peer reviewed papers along with other geophysical results of this cruise. Heat flow data are publicly available after publication.

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1.3. HYDROTHERMAL ACTIVITY ALONG THE MAGMA-STARVED OBLIQUE SEGMENT OF THE SWIR (11-15°E)

1.3.1 Fluid and rock sampling

W. Bach, N. Jöns, C. Hansen (MARUM/FB5), M. D'Errico (U Stanford), J. Warren (not on board, U Stanford)

Objectives

The ultra-slow spreading SWIR features an unusual abundance of exposed mantle peridotite. The 400-km long section between 10° and 16°E, surveyed by *Knorr* Cruise 162, Legs VII to IX, is exceptional in this regard with only partially serpentinized peridotite and scattered basalt exposed over much of the seafloor (Dick et al., 2001). Spreading along this segment is highly oblique (56°) resulting in an effective full spreading rate of 8.4 mm yr^{-1}, one of the lowest for any known section of the global ridge system studied to date including the explored sections of the Gakkel Ridge (Dick et al., 2003). Moreover, the geometry of the rift valley differs strikingly from that of normal ridge segments, with single large low-angle fault surfaces, with typical 1.2 km throw and 6 km heave comprising the rift valley walls. These fault surfaces expose enormous outcrops of partially serpentinized mantle peridotite, often on both sides of the rift valley. A previous survey of the 10°–16°E segment reveals that the lithosphere between prominent volcanic centers between 11.2°E and 14.3°E is dominantly composed of partially to completely serpentinized peridotite as indicated by magnetic and gravity data as well as by an analysis of lithologic proportions in the dredge hauls (Dick et al., 2001).

A cursory plume survey revealed hydrothermal plume characteristics that indicate firm evidence for two active vent sites and tentative evidence for as many as three others (Bach et al., 2002). Fossil hydrothermal material was recovered in 6 of the 38 dredge hauls and includes an occurrence of partially oxidized sulfide breccias, four deposits of sepiolite and silica, as well as Mn-oxide and nontronite cemented breccias. The abundance of hydrothermal material and the frequency of localized hydrothermal activity is remarkable because the mantle upwelling and magma supply rates, and hence the magmatic heat input, along this section of the SWIR are lower than on any other explored segment of the global mid-ocean ridge system. This observation suggests that high mantle upwelling and magma supply rates are not required to drive mid-ocean ridge hydrothermal systems and that a close relationship between magmatic heat input and hydrothermal activity may not be established at the ultra-slow end of the ridge spreading spectrum. The observations of primordial helium at the Gakkel Ridge, an ultra slow spreading ridge in the Arctic, show an apparent discrepancy between the hydrothermal output and the spreading rates established for faster spreading ridges (Jean-Baptiste and Fourré, 2004), making helium a useful tool to assess the characteristics of the hydrothermal circulation at these ultra slow spreading ridges.

The clearest hydrothermal plume signals were detected between 13.15 and 13.60°E, on the wall of a continuous, shallow dipping (18°), lenticular fault block 35 km long and14 km wide (Bach et al., 2002). The footwall of this fault block rises 1200 m up a smooth continuous slope from the rift valley floor to the crest of the rift valley wall. A plume transect constructed from profile downcasts in this area shows a prominent Nephelometric Turbidity Units (NTU) maximum at sites around 13.35°E and between 3,700 and 4,100 m (Bach et al., 2002). The above-bottom maximum at 13.32°E is particularly suggestive of a hydrothermal plume and is accompanied by a local temperature increase of 0.01°C. Both NTU and temperature records registered substantial increases centered near the 4,000 m isobath; the NTU distribution also shows a lesser maximum near 3,800 m. This distribution is consistent with a source near 4,000 m creating a neutrally buoyant plume centered around 3,800 m, spreading laterally into both the axial valley and the southern rift wall. The frequency and distribution of hydrothermal activity in the study area may reflect a largely tectonic control on fluid circulation, with hydrothermal vent sites being preferentially associated with long-lived faults that provide fluid pathways.

The specific goals for the hydrothermal program of the cruise are to:

- Locate hydrothermal vents in the 13.1 to 13.6°E area.
- Determine the spatial extent and the heat and chemical magnitude of the plume
- Determine the concentration and isotopic ratios of helium and neon.

Work at sea

To localize hydrothermal vents, it will be necessary to observe the (non-buoyant) water column plume of the site and infer the source of the plume from the distribution of the plume parameters as turbidity, redox potential (Eh), Mn, CH_4, and the environmental parameters as background flow and stratification. The detection of a hydrothermal vent site is greatly facilitated by the use of MAPR (Miniature Autonomous Plume Recorder measuring temperature, turbidity, and Eh (Baker and Milburn, 1997)). To detect a vent site, the water column plume is mapped in detail with a seesawing CTD/Rosette system (Tow-yo CTD). Particle plumes are often highly variably in space and time, so simultaneous resolution and coverage in the horizontal and vertical is vital; this is implemented by clamping the plume recorder onto the CTD wire (typically 5 MAPR with a vertical interval of 50 m) thus increasing the vertical coverage of the temperature, turbidity and Eh measurements. A turbidity sensor similar to the equipment of the MAPR will be mounted to the CTD system to allow for online plume detection and targeted sampling of the water column plume. Current meters (Lowered Acoustic Current Profiler, LADCP) will be attached to the CTD/Rosette to interpret the observed plume signals in terms of the horizontal current. The present proposal complements the results of the recent cruise MSM25 (Devey, Walter et al. 2013) and the existing helium data set at the IUP, with the overarching aim to quantify the hydrothermal input in terms of primordial helium in the South Atlantic on a basin scale.

After retrieval of the CTD/Rosette, water samples are filled in glass vials for measurements of He concentration and $^{3}He/^{4}He$ isotopic ratios (Roether et al., 2013). The samples will be analyzed on shore with with a high resolution mass spectrometer (MAP 215–50) at the IUP (Sültenfuß et al., 2009). Next, sample aliquots for ship-based measurement of methane concentrations are removed from the rosette water bottles. An aliquot for colorimetric Mn analyses on board is collected next. A gas chromatograph and a UV vis system will be installed in one of the ship's laboratories for these analyses. Finally, samples are collected into 30ml PE bottles for post-cruise metal analyses. These sample solutions are brought to a pH of 1.8 by adding concentrated supra-pure hydrochloric acid. This treatment will prevent hydrolysis and precipitation of transition metals from sample solution during transport and storage.

Rocks collected by dredge or TV grab will be sampled for detailed geochemical and isotopic analyses at Stanford University. These studies will focus on fresh clinopyroxene, which preserves the original signature of the mantle and allows reconstructions of spreading-related decompression and melt flux. Hydrothermal precipitates and rock alteration will be described on board, and samples will be collected for detailed geochemical and petrographic studies at the FB5, University of Bremen.

Sample and data management

Samples of rocks and fluids will be split on board for individual anaylses and aliquots of both types of samples will be kept in storage at the University of Bremen (FB5). All georeferenced physcial and chemical data that come out of the plume survey work will be deposited in the PANGAEA data base. Rock geochemical data will be submitted to the PANGAEA and PetDB data bases.

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1.3.2 Oceanography

M. Vogt (MARUM/UHB-IUP), T. Hannemann, K. Hans (UHB-IUP),
M. Walter (lead oceanographer, not on board, UHB-IUP)

Objectives

The main objective of the oceanography group will be the search for hydrothermal vents in the research area. Further goals are to study the dispersal of hydrothermal plume material on a ultraslow spreading ridge, determine the heat and chemical fluxes of the vents, and to estimate the vertical mixing of the water above the ridge crest and in the axial valley in dependence of the ridge morphology. These goals will be pursued in close collaboration with the plume chemistry group (W. Bach, N. Jöns, and C. Hansen), with whom we will jointly run the CTD program and who will take water samples for Mn and CH_4 analysis. A hydrothermal plume signal can be identified either by negative anomalies in temperature and salinity and/or an increase in turbidity and drop of oxygen reduction potential (Eh). Hence, measurements of temperature, salinity, turbidity, and velocity will be conducted to study the plume dispersal. Water samples with high vertical resolution will be taken to be analyzed for helium and neon isotopes later in the noble gas lab (Univ. Bremen). Water in hydrothermal plumes is highly enriched in helium (isotopes: ^{3}He and ^{4}He); comparison of the He/Ne ratios with that of water outside the plumes and with air shows 5 - 8 times higher ratios within the plume. The primordial components of helium isotopes are ideal tracers for the distribution of vent fluids in the water column, since they are non-reactive and detectable over long distances away from the source. Direct current measurements parallel to the CTD casts will be used for the calculation of finescale velocity shear to estimate diapycnal mixing above the ridge crest, and to interpret the dispersal of plume signals in the axial valley.

Work at sea

CTD work will consist of standard stations at different locations as well as so-called tow-yos, where the ship is moving while the instrument package is lowered and heaved repeatedly in a certain depth range. Tow-yos are used for a high horizontal resolution mapping of a water column plume once a plume signal is detected; the resulting transect of plume properties allows to narrow down the location of a potential vent site as a groundwork for the operation of video techniques for the final localization. Miniature Autonomous Plume Recorder (MAPR, Baker and Milburn, 1997) that record (offline) temperature, pressure, turbidity, and Eh will be attached to the CTD cable to increase the vertical resolution of the tow-yos and to capture possible signals in Eh. Turbidity on the CTD will be measured using a custom build Seapoint Turbidity Meter (5x normal gain), the same sensor that is used on the MAPR. Direct current measurements will be carried out using a lowered acoustic Doppler current profiler system (LADCP), where two current meters are attached to the CTD instrument package. Water samples for helium and neon will be taken in glass ampoules (Roether et al., 2013), where water is drawn into evacuated glass ampoules with subsequent flame sealing. This Ampoule-based Water Sampler (AWS) was developed to minimize the delay between sampling and measurement by combining sample collection and gas extraction in one step. The samples will be analysed after the cruise in the Bremen Mass Spectrometer Laboratory (helis Lab).

Preliminary (expected) results

Earlier studies have evidence for two active vent sites in the 13.3 to 13.5°E area, and tentative evidence for as many as three others (Bach et al., 2002); with a targeted strategy of tow-yoing, we hope to locate the prospective hydrothermal vents, determine the spatial extent and the heat and chemical magnitude of the plume, and to determine concentration and isotopic ratios of helium and neon.

Data management

Uncalibrated CTD data will be available for all cruise participants on board. Data calibration will be done right after the cruise and the data will be made available for all cruise participants.

The data will be made public on the PANGAEA data base as soon as we have the trace-gas data available (approx. one year after the cruise), all data is carefully quality controlled and published in a peer reviewed journal.

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1.4 DEEP-SEA ECOLOGY, BIOGEOCHEMISTRY AND SYMBIOSIS OF THE SOUTH WEST INDIAN RIDGE

A. Boetius (AWI), S. Albrecht (FIELAX), D. de Beer (MPI-Bremen), S. Galkin (Shirshov Institute), J. Hoops (iSiTEC), Y. Marcon (MARUM), M. Molari (MPI-Bremen), A. Nordhausen (MPI-Bremen), A. Nunes (MPI-Bremen), W. Rentzsch (MPI-Bremen), R. Stiens (MPI-Bremen), not on board: G. Bohrmann (MARUM), C. Borowski, N. Dubilier, (MPI Bremen), A. Gebruk (Shirshov Institute)

Objectives

The geographic remoteness of spreading ridges in the Southern Ocean raises fundamental questions about the evolution and ecology of their biological communities (Van Dover et al., 2002, Bachraty et al., 2009). It has been hypothesized that vents and seeps at high southern latitudes may act as stepping stones for dispersal and exchange of species between the very different vent communities found at Pacific, Atlantic, and Indian Ocean hydrothermal vents. Hydrothermal vent communities were first observed in the Indian Ocean on the intermediate-spreading Central Indian Ridge (CIR) in 2000 (Hashimoto et al., 2001; Van Dover et al., 2001). The fauna of CIR vents exhibit taxonomic affinities with those of the western Pacific, although sites are also dominated by a species of alvinocaridid shrimp closely related to that found at deep Mid-Atlantic vents (Watabe & Hashimoto, 2002; Komai et al., 2007; Komai & Segonzac, 2008). At a global scale, differences between vent biogeographic provinces largely reflect their degree of separation along the ridge system (Tunnicliffe & Fowler, 1996). At present the only ridge-crest connection between the Atlantic and Pacific is via the Indian Ocean, with a substantial discontinuity where the ultraslow-spreading SWIR meets the intermediate-spreading CIR and SE Indian Ridge (Baker et al., 2004). However, the fauna and in particular the invertebrate-bacteria symbioses at active vent sites on the SWIR are unknown. The knowledge gained by filling this gap will significantly contribute to our understanding of the migration pathways and evolution of hydrothermal symbioses on a global scale.

A main objective is to test whether the SWIR provides a gateway for dispersal of vent species between the Mid-Atlantic Ridge to the ridges of the Indian Ocean. Generally, also for the non-chemosynthetic deep-sea fauna of the deep SW Indian Ocean it has been concluded previously that it is less endemic than that of the Atlantic and Pacific (Vinogradova et al., 1958), but very little data have been obtained for the hard-bottom fauna. The exploration of the SWIR will thus provide crucial data for understanding dispersal and colonization pathways for chemosynthetic organisms and associated fauna between ocean basins. In addition, the SWIR provides an opportunity to examine the influence of spreading rate and water depth on the biogeography of vent fauna. The former Census of Marine Life program ChEss has identified this ridge segment as a priority area to elucidate global biogeographic patterns and processes in chemosynthetic ecosystems (ChEss Steering Committee, 2007).

AWI's Deep-sea ecology and technology group and the Benthos group of the Shirshov Institute will analyze the distribution of the megafauna at the investigated SWIR segment, and will combine environmental information including seafloor and bottom water biogeochemistry and microbiological activity, to assess the ecology of deep-sea ecosystems at the SWIR. This will include the *in-situ* study of gradients around active vents characterized by redox signals, for example from sulphide emission with the help of sensor modules attached to video-guided instruments (MPI microsensor group). We will also check for gas flares by Parasound-enabled surveys. The assessment of biogeochemical and microbiological signatures in proximity of hydrothermal vents – e.g. redox, sulphide, methane, turbidity plumes and their sources - will be carried out in close collaboration with the oceanography, petrology, and heat flux groups. Members of MARUM and FIELAX are responsible to combine all environmental information into geo-referenced maps.

The MPI Bremen Symbiosis Group will investigate the diversity and biogeography of symbioses at hydrothermally active sites and in sunken wood. For this purpose, colonization experiments containing wood blocks and substrates for the settlement of microbial organisms were deployed on the SWIR between 52°1.14'S - 52°17.7'S and 12°50.07'E - 13°45.82'E together with ten ocean bottom seismometers (OBS) during *Polarstern* cruise leg ANT-XXIX/2 in December 2012. After recovery, the colonizers will be analyzed for symbiotic wood-boring bivalves and free-living stages of microbial hydrothermal vent symbionts. If active vents will be localized on the seafloor, the diversity, biogeography and function of hydrothermal symbioses will be investigated using taxonomy, molecular methods and isotopic signatures.

Together we will contribute towards several of the main goals of the mission, including

- Localization and characterization of hydrothermal vents and mapping to determine structural controls on vent distribution
- Sampling of hydrothermal fluids to determine (a) high-temperature water-rock interactions in the deep root zone of the systems, (b) fluid mixing and cooling processes in the sub-seafloor and potential linkages to microbial activity
- Analyses of vent communities to determine dispersal and colonization pathways along spreading ridges

Work at sea

Main tools for the exploration surveys following the CTD and MAPR transects as well as the Parasound enabled gas flare detection will be the video-guided, winch-operated instruments, which will be geo-referenced by POSIDONIA transponders, allowing both the characterization of bottom near environmental parameters (e.g. via the Microsensor-Profiler and temperature probes mounted to the OFOS and the TV-guided MUC), as well as a visual analysis of habitats and megafauna. High resolution towed camera surveys with photos and videos are a key method to determine the density and distribution of deep-sea megafauna, documenting spatial patterns at a high resolution and showing the organisms *in-situ*, and in association with their immediate habitat. To analyze the photo and video material, we will use a combination of mapping and image analysis tools to extract quantitative information from large amounts of geo-referenced images. The sampling of rocks, sediments, microbiota and fauna from the SWIR will fill gaps in the global biogeography of benthic and animal-associated microbial communities, and - if vents are located – will help to assess the composition and distribution of hydrothermal vent communities and their key energy supplies. Therefore we will deploy gravity corer, dredges and multiple corer systems as well as the TV grab, depending on the weather situation and the seafloor features. Colonization experiments for symbiotic organisms will be recovered together with the OBS deployed during cruise leg ANT-XXIX/2. Wood-colonizing animals will be extracted from the wood blocks and symbiont containing tissues will be dissected. Surfaces of the colonization experiments and dissected tissues of wood-boring bivalves will be processed for molecular analyses in the home laboratories. Animals from active vents on the SWIR will be collected using the TV grab and processed on board for photography, molecular and isotopic analyses in the home laboratories.

Sample and data management

Care will be taken to deploy the TV grab according to the Code of Conduct for responsible research practices at hydrothermal vents (http://www.interridge.org/IRStatement), i.e. avoid sampling that would cause long-lasting deleterious effects. Specimens for morphological phylogenetic analyses will be fixed and sent to the corresponding taxonomic experts, in collaboration with the Shirshov Institute and Senckenberg Research Institute and Museum. For molecular analyses, we will fix the specimens on board and use multi locus sequencing in the home laboratory for examining the taxonomy and phylogeny of vent biota and their symbiotic microorganisms. All biogeochemical data will be quality checked, stored and made available through PANGAEA. Biological data will be submitted to the OBIS database. Tracks of video and photography surveys will be stored in PANGAEA; the photographic material will be made available to taxonomists and further image analysis via BIIGLE. Microbiological sequence data will be archived in GenBank.

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1.5 BATHYMETRY OF THE SOUTHWEST INDIAN RIDGE

L. Jensen, I. Egelkraut, K. Gersberg (AWI)

Objectives

Detailed knowledge of the seafloor topography is a basic requirement for understanding many marine processes. Therefore, for a comparative study of the active tectonic and hydrothermal processes at the SWIR, accurate and high-resolution bathymetric maps are a key requirement. Topographic maps of the region will help to find sampling sites and will provide information for detailed cruise planning.

In order to detect hydrothermal vents in the survey area, high-resolution bathymetric data and water column data will be recorded. Especially the water column data will support the search for vent sites. Bathymetric data will also form an important basis for video surveys with towed camera systems like OFOS and target sampling with the TV grab.

As seafloor topography measurements with the echosounder are largely independent from weather conditions, bathymetric surveys will be conducted when no biological or geological devices can be deployed due to rough sea. Thereby existing datasets can be extended and gaps can be filled.

For the survey area, limited high-resolution multibeam coverages were recorded with the research vessel *Knorr* (KN162L07 and KN162L09 from 12/2000 to 01/2001). It is envisaged to extend these coverages. Furthermore, so far no water column or sub-bottom data exist for the study area. Outside the existing multibeam coverages, only topographic data derived from satellite altimetry exist. Satellite altimetry data is however too uncertain and too large-scaled to resolve small seafloor features like hydrothermal vents.

In addition to bathymetric seafloor measurements with the multibeam echosounder ATLAS Hydrosweep DS3, high-resolution sub-bottom data will be collected with the sediment echosounder ATLAS Parasound P70 during this cruise.

Work at sea

During the cruise, high-resolution bathymetry and sub-bottom sedimentary data will be collected by three operators in a 24/7 shift mode. The raw bathymetric data will be corrected for sound velocity changes in the water column and cleaned from coarse errors and artifacts. Seafloor maps will be made available for the other working groups for sampling site selection as well as survey and cruise planning. During the search for hydrothermal vents, the Hydrosweep water column data and the Parasound data will be carefully examined for indication of gas plumes and leaking fluids.

As a contingency, the bathymetry group will plan bathymetric surveys in the study area to extend and complement the existing datasets.

Preliminary (expected) results

Results will be detailed bathymetric maps and seabed information of the survey area. The multibeam and sediment acoustic data will be analyzed to provide environmental information for the SWIR and to help understanding the tectonic, magmatic and hydrothermal processes at the ridge. In case of the discovery of a hydrothermal vent, the recorded water column data can be analyzed together with the visual data of the towed camera devices. This would be one of the first applications of Hydrosweep water column data collected with *Polarstern.*

Data management

All hydro-acoustic data (multibeam and sediment echosounder) collected during the expedition will be stored in the PANGAEA data repository at the AWI. The data will be provided to regional and global mapping projects such as GEBCO (General Bathymetric Chart of the Ocean).

1.6 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

Institution	Address
AWI	Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research Am Handelshafen 12 27515 Bremerhaven Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
FB5	Fachbereich 5 Geowissenschaften der Universität Bremen GEO Gebäude Klagenfurter Straße 28359 Bremen Germany
FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schleusenstr. 14 D-27568 Bremerhaven Germany
HGF MPG	HGF MPG Research Group on Deep Sea Ecology and Technology Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research Am Handelshafen 12 27515 Bremerhaven Germany
iSiTEC	iSiTEC GmbH Bussestr. 27 27570 Bremerhaven Germany
MARUM	MARUM Center for Marine Environmental Research University Bremen Leobener Str. D-28359 Bremen Germany

Institution	Address
MPI-Bremen	Max-Planck-Institut für Marine Mikrobiologie Celsiusstr. 1 28359 Bremen Germany
UHB-IUP	Universität Bremen Institut für Umweltphysik/ Sektion Ozeanographie Otto Hahn Allee 1; Gebäude: NW1 28359 Bremen Germany
Shirshov Institute	P.P. Shirshov Institute of Oceanology Russian Academy of Sciences Nakhimovsky Pr., 36 Moscow 117997 Russia
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1.7 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

	Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**
1.	Albrecht	Sebastian	Fielax	Technician, data management, parasound
2.	Bach	Wolfgang	MARUM/UHB-GEO	Group leader, rock/ plume water chemistry
3.	Boetius	Antje	HGF MPG Group (AWI)	Group leader, deep-sea ecology
4.	Coers	Susanne	AWI	Student, seismology
5.	D'Errico	Megan	U Stanford	Scientist, rock sampling
6.	De Beer	Dirk	Microsensor Group MPI-Bremen	Scientist, microsensors
7.	Egelkraut	Ines	AWI	Student, bathymetry
8.	Galkin	Sergey	Shirshov Institute	Scientist, zoology
9.	Gersberg	Karolin	AWI	Student, bathymetry
10.	Hannemann	Tim	UHB-IUP	Student, oceanography
11.	Hans	Kerstin	UHB-IUP	Scientist, oceanography
12.	Hansen	Christian	FB5	Scientist, plume water chemistry
13.	Heesemann	Bernd	FB5	Technician, heat flow
14.	Hochmuth	Katharina	AWI	Scientist, seismology
15.	Hoops	Jan	iSiTEC	Technician, videomapping
16.	Jensen	Laura	AWI	Group leader, bathymetry
17.	Jöns	Niels	FB5	Scientist, rock/ plume water chemistry
18.	Kaul	Norbert	FB5	Group leader, heat flow
19.	Kirk	Henning	AWI	Technician, OBS
20.	Lange	Florian	AWI	Engineer, ship construction
21.	Lensch	Norbert	AWI	Technician, air guns
22.	Marcon	Yann	MARUM	Scientist, videomapping
23.	Molari	Massimiliano	HGF MPG Group (MPI-Bremen)	Scientist, microbiology
24.	NN			Microbiology
25.	Nordhausen	Axel	HGF MPG Group (MPI-Bremen)	Technician, TV grab
26.	Nunes-Jorge	Amandine	Symbiosis Group MPI-Bremen	Student, symbiosis
27.	Rentzsch	Wiebke	HGF MPG Group (MPI-Bremen)	Technician, biogeochemistry
28.	Schlindwein	Vera	AWI	Chief scientist, seismology
29.	Schmid	Florian	AWI	Student, seismology
30.	Scholz	John-Robert	AWI	Student, seismology
31.	Stiens	Rafael	HGF MPG Group (MPI-Bremen)	Technician, biogeochemistry
32.	Thiel	Daniel	FB5	Student, heat flow
33.	Vogt	Martin	MARUM/UHB-IUP	Group leader, oceanography

1.8 SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Pahl, Uwe	Master
Spielke, Steffen	1.Offc.
Ziemann, Olaf	Ch.Eng.
Lauber, Felix	2.Offc.
NN	2.Offc.
Hering, Igor	2.Offc.
Spilok, Norbert	Doctor
Koch, Georg	R.Offc.
Kotnik, Herbert	2.Eng.
Schnürch, Helmut	2.Eng.
Westphal, Henning	2.Eng.
Brehme, Andreas	Elec.Tech.
Ganter Armin	Electron.
Dimmler, Werner	Electron.
Winter, Andreas	Electron.
Feiertag, Thomas	Electron.
Schröter, Rene	Boatsw.
Neisner,Winfried	Carpenter
NN	A.B.
Clasen, Nils	A.B.
Burzan, Gerd-Ekkehard	A.B.
Schröder, Norbert	A.B.
Moser, Siegfried	A.B.
Hartwig-L., Andreas	A.B.
Kretzschmar, Uwe	A.B.
Kreis, Reinhard	A.B.
Gladow, Lothar	A.B.
Beth, Detlef	Storekeep.
Plehn, Markus	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Dinse, Horst	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy,Mario	Cooksmate
Völske, Thomas	Cooksmate
Dinse, Petra	1.Stwdess
Hennig, Christina	Stwdss/KS
Streit, Christina	2.Steward
Hischke, Peggy	2.Stwdess
Wartenberg, Irina	2.Stwdess
Hu, Guo Yong	2.Steward
Chen, Quan Lun	2.Steward
Ruan, Hui Guang	Laundrym.

ANT-XXIX/9

19 December 2013 - 05 March 2014

Cape Town - Cape Town

Chief Scientist
Rainer Knust

Coordinator
Rainer Knust

2. EXPEDITION ANT-XXIX/9

2.1. ÜBERBLICK UND FAHRTVERLAUF

Rainer Knust (AWI)

Das Meeresgebiet vor dem Filchner-Schelfeis wurde als ein ozeanographisch wie biologisch besonderes Gebiet im südlichen Weddellmeer identifiziert, in dem der Abfluss von Schelfeiswasser (Ice Shelf Water - ISW) des Filchner Ronne-Schelfeises mit wärmerem Tiefenwasser des Weddellwirbels interagiert. Das Gebiet ist ein wichtiger Bereich für die Bildung von Weddellmeer-Tiefen- und Bodenwasser (Weddell Sea Deep and Bottom Water - WSDW und WSBW) und ist daher für die globale Ozeanzirkulation von großer Bedeutung. Diese hydrographischen Gegebenheiten sind sehr wahrscheinlich auch die primäre Ursache dafür, dass dieses Gebiet ein biologischer "Hotspot" ist. Hinweise dazu finden sich in jüngsten Untersuchungen über das Migrations- und das Ernährungsverhalten der südlichen Seeelefanten. Die in dieser Studien erzielten Daten zeigen deutlich längere Verweilzeiten der Seeelefanten von bis zu drei Monaten im Bereich des Filchner-Abflusses, sowohl im Sommer, als auch im Winter. Aus älteren Untersuchungen aus den 1980er Jahren ist zu ersehen, dass die Region durch ein hohes Vorkommen verschiedener Arten von Meeressäugern gekennzeichnet ist und es weist im Vergleich zu anderen Gebieten des Weddellmeeres eine höhere Produktion im pelagischen System auf. Dies gilt insbesondere für den Antarktischen Silberfisch, der in diesem Bereich des Weddellmeeres einen besonders hohe Biomasse und Produktion aufweist und damit eine wichtige Nahrungsquelle für Meeressäuger darstellt.

Die Bildung von Tiefen- und Bodenwasser (WSDW/WSBW) im südlichen Weddellmeer wird stark durch Strömung von Schelfeiswasser (ISW) aus dem Filchner-Ronne Schelfeis beeinflusst. Eigene hydrographische Messungen mit *Polarstern* im Jahr 1995 entlang der Filchner-Schelfeisfront zeigen, dass der Abbruch von drei sehr großen Eisbergen im Jahr 1986 und deren Gründung auf der flachen Berkner Bank, die Zirkulation und die Wassermassenbildung im Filchner-Trog signifikant modifiziert hat. Auch die angrenzenden Seegebiete zeigen deutliche Veränderungen in den Wassermassencharakteristika und Strömungsmustern im Vergleich zu Messungen aus den frühen 1980er Jahren. Ein neueres Modellszenario zeigt, dass klimabedingte Veränderungen des Küstenstroms in den Filchner-Trog und unter das Filchner-Ronne-Schelfeis im einundzwanzigsten Jahrhundert zu einem erhöhten Zufluss von warmem Wasser (Modified Warm Deep Water - MWDW) in dieses Gebiet führen werden und die Wassertemperatur dabei um mehr als 2°C steigen kann. Die Folge davon sind höhere Abschmelzraten des Schelfeises. Eine höhere Schelfeisdynamik mit häufigeren Eisbergstrandungen und eine Erhöhung der Wassertemperatur werden erheblichen Einfluss auf die Artenvielfalt des südlichen Weddellmeer haben.

Die wichtigsten Ziele der ANT-XXIX/9 (**FOS**) Expedition sind:

1. Charakterisierung der hydrodynamischen Prozesse und Wassermassen im Filchner-Ausfluss-System (Filchner Outflow System - FOS). Dabei soll die Rolle der Meeresbodentopographie für die Wassermassenzirkulation ebenso erfasst werden,

wie die Raten von Tiefen- und Bodenwasserbildung unter Einbeziehung der Schmelzraten des Schelfeises.

2. Eine Abschätzung von möglichen Veränderungen dieser hydrographischen Prozesse durch rezente Veränderungen des antarktischen Klimas.
3. Untersuchungen zur biologischen Produktion im Filchner-Ausflusssystem und zu den Energieumsatzraten im trophischen Nahrungsnetz bis hin zu den Robben, als Topprädatoren im System.
4. Eine Abschätzung des Einflusses von möglichen Veränderungen hydrographischer Gegebenheiten und der Schelfeisdynamik auf die Biodiversität und die Ökosystemfunktion im Filchnergebiet.

Die Expedition ANT-XXIX/9 (Filchner Outflow System, **FOS**) wird am 19. Dezember 2013 in Kapstadt, Südafrika, beginnen. *Polarstern* wird direkt die Atka-Bucht anlaufen, um die NEUMAYER III Station zu versorgen (Abb.1). Das wissenschaftliche Programm wird im Gebiet Austasen, südwestlich der Akta Bucht beginnen. Für zwei Tage wird das BENDEX Gebiet aufgesucht (**BENDEX-F2**), in dem im Jahr 2003/04 ein Benthos-Störungsexperiment durchgeführt wurde. Nach 2011 (ANT-XXVII/3, **CAMBIO**) wird dies die zweite Überprüfung dieses Gebietes sein, um die Wiederbesiedlung in diesem Gebiet nach 10 Jahren zu untersuchen. Der kurze Aufenthalt bei Austasen wird ebenfalls dazu genutzt, lebende Tiere für erste Laborexperimente an Bord zu fangen.

Weiter südlich auf dem Weg zum Filchner Gebiet werden zwei hydroakustische Verankerungen ausgebracht, die zur Navigation der RAFOS Bojen im südlichen Weddellmeer dienen. Dies ein Teil des internationalen ARGO Experiments.

Das wissenschaftliche Hauptprogramm wird im Meeresgebiet vor dem Filchner-Ronne-Schelfeis durchgeführt. Sollten die Eisverhältnisse ein Eindringen in dieses Gebiet nicht erlauben, wird ein Alternativgebiet nördlich davon untersucht. Ein intensives CTD-Programm wird die hydrographischen Parameter aufnehmen und Wasserproben sammeln, um die unterschiedlichen Wassermassen zu identifizieren. Das geplante Stationsnetz ist in Abb. 2 dargestellt. Drei Langzeit-Verankerungen sollen im Gebiet ausgebracht werden, ergänzt durch eine Kurzzeitverankerung während der Untersuchungszeit. Die Meeresbodentopographie und Sedimentcharakteristika werden mit Hilfe des Fächersonars DS-III und mit Hilfe von Parasound untersucht. Um die Rolle des Meereises für die biologischen Prozesse zu untersuchen, sollen Meereisproben gewonnen und bio-optische Messmethoden direkt auf dem Eis angewendet werden. Zur Bestimmung der Massen- und Energiebilanz des Meereises werden in enger Kooperation mit den Meereisphysikern Bojen mit autonomen Messlaboratorien auf dem Eis ausgebracht und Eisbeobachtung entlang der Fahrtroute durchgeführt.

Die biologischen Untersuchungen beinhalten Wasserproben und Planktonfänge zur Bestimmung der Primärproduktion, der Verteilung von Planktonorganismen und deren Biomasse. Produktionsraten des Zooplanktons sollen anhand von Laborexperimenten an Bord bestimmt werden. Die Verteilung und Biomasse pelagischer Fische wird mit Hilfe von Netzfängen ermittelt. Die Bestimmung der Verteilung und des Vorkommens von Benthosarten und demersalen Fischen, sowie die Bestimmung ihrer Biomasse wird durch videogeführte Bodengreifer, Multicorer, Agassiz Trawls und mit Hilfe von Grundschleppnetzfängen durchgeführt. Zur Ermittlung der räumlichen Verteilung werden auch HD Video Transekte mit einem Unterwasserfahrzeug (ROV) durchgeführt. Daten zu Produktionsraten des Benthos und der Fische werden mit Hilfe der Biomassedaten anhand standardisierter Rechenverfahren bestimmt und durch Laborexperimente an Bord und in den Heimatlaboratorien unterstützt. Das Vorkommen und die räumliche Verteilung von Robben im Untersuchungsgebiet wird durch Zählungen vom Helikopter aus bestimmt. Diese Zählungen sind eng mit einer flugzeuggestützten Messkampagne zur großräumigen Zählung von Roben mit POLAR 6 verzahnt, die im Oktober 2013 von Halley Bay aus durchgeführt werden soll. Satellitentransmitter, die an Robben befestigt werden, werden darüber hinaus Daten zum Tauchverhalten der Robben und zur Hydrographie liefern.

Die Bentho-pelagischen-Kopplungsprozesse sollen durch Kurzzeitverankerungen erfasst werden, die mit Strömungsmessern und Sedimentfallen bestückt sind. Ergänzt werden diese Messungen durch *in-situ* Experimente, die mit dem ROV durchgeführt werden und durch biochemische Messungen des Sediments und der gelösten organischen Substanzen (dissolved organic matter - DOM). Proben zur Untersuchung des Nahrungsnetzes (Stabile Isotope, Mageninhaltsuntersuchungen), der Bioenergetik, der Ökophysiologie und zur Genetik werden von ausgewählten Organismen gewonnen, um später im Labor gemessen zu werden. Des Weiteren sollen lebende Tiere gefangen werden, um für Laborexperimente an Bord oder zum Transport nach Bremerhaven zur Verfügung zu stehen.

Die Expedition wird am 5. März 2014 in Kapstadt, Südafrika enden.

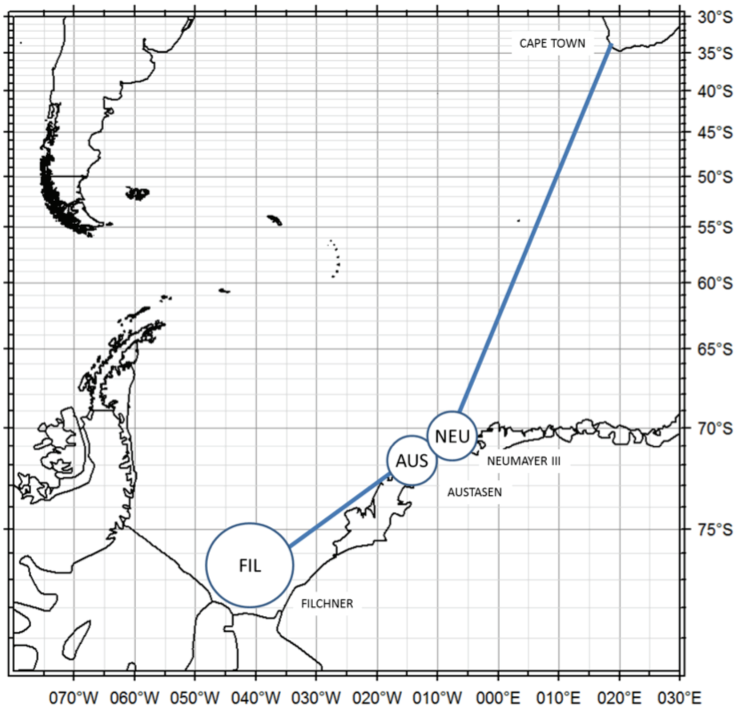

Abb. 2.1 : Die geplante Fahrtroute und die Arbeitsgebiete
Fig. 2.1 : Planned cruise track and working areas

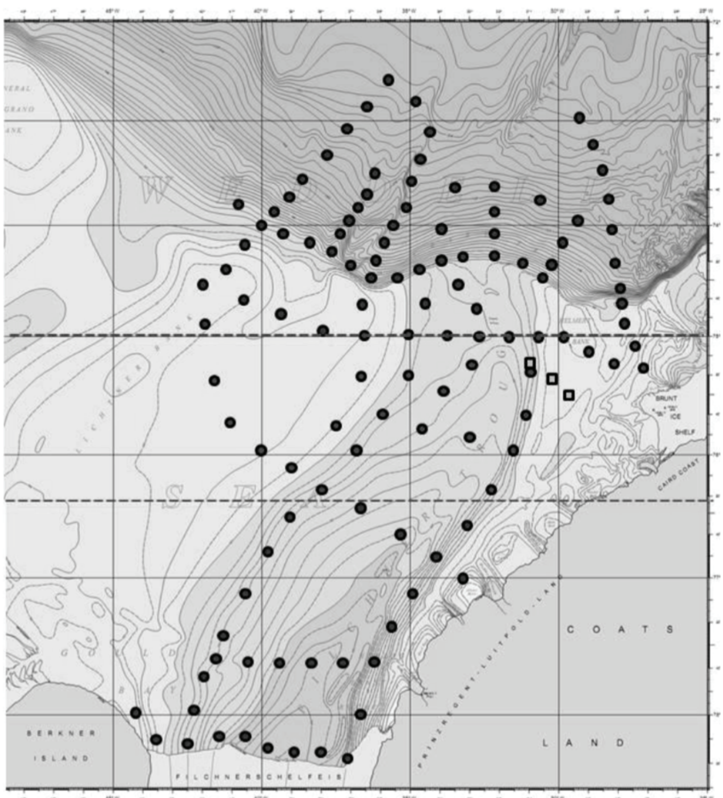

Abb. 2.2: Das geplante CTD Stationsgrid
Fig. 2.2: Planned station grid for CTD and moorings

SUMMARY AND ITINERARY

The marine vicinities of the Filchner Ice Shelf have been identified as a special area in the southern Weddell Sea, where the outflow of Ice Shelf Water (ISW) of the Filchner Ronne Ice Shelf interacts with warmer deep water of the Weddell Gyre. The region is a key area for the formation of Weddell Sea Deep and Bottom Water (WSDW and WSBW) and therefore of major importance for the global ocean circulation. These hydrographical features are supposed to be the primary cause converting this region into a biological "hotspot" indicated by recent investigations on the migration and foraging behaviour of southern elephant seals. These studies achieved data on extended residence times of the seals in the area of the Filchner Outflow of up to three months, both in summer and winter. Previous investigations from the 1980's tell us that the region is characterized by high abundances of different warm blooded species and a higher production in the pelagic system as compared to other regions of the Weddell Sea. This holds especially true for the Antarctic silverfish with its high biomass and production values, which is an important food source for marine mammals in the upper food web.

The formation of deep and bottom water (WSDW/WSBW) in the southern Weddell Sea is strongly influenced by flow of Ice Shelf Water (ISW) out of the Filchner-Ronne Ice cavity. Own hydrographic measurements along the Filchner Ice Front carried out with *Polarstern* in 1995, show that the breakout of three giant icebergs in 1986 and their grounding on the shallow Berkner Bank still modified the circulation and water mass formation in the Filchner Trough. Even the adjacent sea areas show significant changes in the water mass characteristics and flow patterns compared to measurements from the early 1980s. A recent model scenario indicates that a redirection of the coastal current into the Filchner Trough and underneath the Filchner-Ronne Ice Shelf during the twenty-first century would lead to increased inflow of warm MWDW waters (Modified Warm Deep Water) into the deep southern ice-shelf cavity accompanied by a water temperature increase of more than 2°C, with the consequence of higher melting rates of the shelf-ice, a higher shelf ice dynamic and a higher habitat water temperature. A higher shelf ice dynamic with higher numbers of iceberg scouring events and an increase in water temperature will significantly influence the biodiversity of the southern Weddell Sea.

The main objectives of the ANT-XXIX/9 (FOS) expedition are:

1. To characterize the hydrographical features and water masses of the Filchner Outflow System (FOS), the role of bathymetry for current patterns, and the deep and bottom water formation rates with the related basal melting rates.

2. To estimate possible changes in these hydrographical features induced by observed change in Antarctic climate.

3. To investigate the high productive Filchner Outflow System as a biological "hotspot", producing a high-energy turnover to subsequent trophic levels up to the seals as top predators of the food web.

4. To estimate the impact of possible changes in the hydrography and increasing shelf and sea ice dynamics on the biodiversity and ecosystem functioning of the southern Weddell Sea.

The expedition ANT-XXIX/9 (Filchner Outflow System, **FOS**) will start in Cape Town, South Africa, on December 19, 2013. *Polarstern* will sail directly to the Atka Bay to supply *Neumayer* Station III (Fig. 2.1). The scientific program will start off Austasen, south westerly from the Atka Bay. For two days we will revisit the BENDEX area (**BENDEX-F2**), where an artificial benthos disturbance experiment was carried out in 2003/04. After 2011 (ANT-XXVII/3, **CAMBIO**) this will be the second visit, to document the recolonisation process after 10 years. The short stay at Austasen will also be used to obtain living animals for first setup laboratory experiments on board *Polarstern*.

Further south on the way to the Filchner Sill two sound source moorings will be deployed to provide navigation data of RAFOS floats in the southern Weddell Sea. This will be part of the international ARGO experiment.

The main scientific program will be performed in the area of the Filchner Ronne shelf area. If the ice conditions do not allow to enter the Filchner region, an alternative research area in the north will be investigated. An intensive CTD program is planned to record hydrographical parameters and to get water samples to identify the different water masses. The station grid is shown in Fig. 2.2. Three long-time moorings will be deployed and one additional short-term mooring (Fig. 2.2). The sea floor topography and sediment characteristics will be investigated with a multi-beam system (DS-III) and parasound. To investigate the role of sea ice for the biological processes, ice cores will be taken and bio-optical measurements in the ice will be conducted. In close cooperation with the ice-physicists the mass- and energy balance of sea ice will be measured by deploying autonomous observatories (ice buoys) and continuous along-track sea ice observations.

The biological investigations will include water samples and plankton catches to estimate primary production, plankton species distribution and biomass. Zooplankton production rates will be measured in laboratory experiments on board. Distribution and biomass of pelagic fish fauna will be estimated by pelagic fishing trawls. Species distribution and biomass of benthic invertebrates and demersal fishes will be measured by video guided grab samples, multi-corer, Agassiz trawls, bottom trawls, and HD video and photo transects operated with a ROV-system (Remote underwater vehicle). Data on production rates of benthos and fishes will be estimated by standardized calculation methods supported by additional laboratory measurements and experiments on board and in the home laboratories. The distribution and abundance of seals in the Filchner area will be investigated by helicopter transects which are closely linked to an aircraft campaign (AWI POLAR 6) conducted in October 2013 with video and photo technics counting seals in a greater area. Satellite transmitters, which will be deployed on seals, will provide data on the seals' foraging behaviour and concurrent hydrographic data.

Bentho-pelagic-coupling processes will be studied by a short term mooring equipped with a sediment trap, by additional *in-situ* experiments with the ROV, and by biochemical and molecular analyses of sediments and dissolved organic matter (DOM). Samples for the investigation of food web properties (stable isotopes, gut content), bioenergetics, eco-physiology and genetics will be taken from selected species. Live organisms for on board experiments will be caught and live animals will be transported to Bremerhaven for ecophysiological experiments in the home laboratories.

The expedition will end on March 5, 2014 in Cape Town, South Africa.

2.2. BATHYMETRIE & PARASOUND (BATFOS)

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H. Sardemann (TU-Dresden)

Objectives

Accurate knowledge of the seafloor topography, hence high resolution bathymetry data, is key, basic information necessary to understand many marine processes. It is of particular importance for the interpretation of biological and geological data in a spatial context. For pelagic ecosystems for example, seabed topography is a key environmental parameter. Depressions in the seabed can act as sediment depot-centres and are therefore often characterised by rather homogeneous soft sediment substrate. Steep slopes and escarpments, on the other hand, can be affected by erosion exposing laterally variable hard substrate. Supplementing the bathymetric data, the sediment echo sounder PARASOUND record high resolution sub-bottom data on the top 10s of meters below the seabed, thus providing information on the sediments at the seafloor and on the lateral extension of sediment successions.

The survey area, the shelf area in front of the Filchner Ice Shelf and in particular the Filchner Trough outflow, has been identified as a biological hot spot. Specific oceanographic conditions in the area are likely the reason for the enhanced biological activity but additional environmental factors presumably have an influence. Seabed topography and substrate for example influence the occurrence and distribution of benthic communities with exposed locations often being more attractive for filter-feeding organism. Also the pathway of water masses across the shelf can be influenced by the seabed topography. Topographically steered, density driven flows follow the deepest path. Interacting with the seabed morphology these flows can result in locally enhanced or reduced bottom currents intensities. Enhanced bottom currents on the other hand can form erosional and depositional sediment features (e.g. furrows, sediment waves) that can be identified on high resolution bathymetric data. These features can then be used to reconstruct past and recent bottom current flows and intensities thus providing environmental information to better understand the factors and processes that influence this biological hotspot.

For the survey area only sparse bathymetric and sub-bottom information exists. For large areas, the bathymetric models are derived from satellite altimetry with only limited direct sounding measurements. For detailed survey planning, the satellite altimetry derived bathymetry often lacks the resolution necessary to resolve small- to meso-scale morphological features. This is especially true for glacial-induced seabed features such as mega-scale glacial lineation and drumlins. Also sedimentological features related to bottom currents as for example scour features and sediment waves cannot be resolved from satellite altimetry data. Therefore, for the reconstruction of palaeo-ice drainage pattern and bottom, ship-borne high resolution bathymetry of the survey areas is required.

Work at sea

The main task of the bathymetry group is to plan and run bathymetric surveys in the survey areas and during transit. The raw bathymetric data will be corrected for sound velocity changes in the water column and will be further processed and cleaned for erroneous soundings and artefacts. Detailed seabed maps derived from the data will provide information on the general and local topographic setting of the area. Simultaneously recorded sub-bottom data provide information on the sedimentary architecture of the surveyed area. High resolution seabed and sub-bottom data recorded during the survey will promptly be made available for site selection and cruise planning. In addition, sediment samples will be collected for groundtruthing the acoustic data and to analyse the physical properties of the sediments in the survey area. During the survey, the acoustic measurement will be carried out by three operators in a 24/7 shift mode.

Preliminary (expected) results

Expected results are high resolution seabed maps and sub-bottom information from the target research sites. The bathymetric and sediment acoustic data will be analysed to provide environmental information for the seabed in front of the Filchner Ice Shelf. Expected outcomes aim towards a better understanding of the biological hotspot in this area.

Data management

Hydro-acoustic data (multi-beam and sediment echo sounder) collected during the expedition will be stored in the PANGEA data repository at the AWI. Furthermore, the data will be provided to mapping projects and included in regional data compilations such as IBCSO (International Bathymetric Chart of the Southern Ocean) and GEBCO (General Bathymetric Chart of the Ocean).

2.3. OCEANOGRAPHY, TRACER, AND SEA ICE PHYSICS (SODFOS)

2.3.1 Observations of the hydrographic conditions and water mass compositions at the Filchner Sill and in the Filchner Trough

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Objectives

The region around the sill of the Filchner Trough Outflow is considered a “hot spot”, both in terms of biology and physical oceanography. The factors contributing to this oceanic area of enhanced food availability and its relation to physical processes are not yet understood, and shall undergo a multidisciplinary in-depth investigation in tandem with application S-2009-7. Based on the fact that polar regions are especially sensitive to climate warming, it can be expected that biological hot spots may undergo substantial transformations linked to environmental changes. The culmination of upper and intermediate trophic level interactions at a hot spot offers the opportunity for paradigm studies to elucidate how climate changes in Antarctica may determine changes elsewhere in the ocean. The combination of CTD casts from aboard *Polarstern* and its helicopters together with animal born satellite telemetry to collect behavioural data in tandem with hydrographic data aims to describe the physical environments passed by the seals during their foraging migrations at sea, and their behavioural responses to the oceanographic features they experience for up to one year tracking time, and thus covering the winter season.

The region around the sill of the Filchner Trough Outflow is also considered as a “hot spot” in physical oceanography because here a major portion of the deep and bottom waters of the Weddell Sea abyss is formed. According to recent IPCC-scenario simulations (Hellmer et al.

2012) the southeastern Weddell Sea is also extremely sensitive to climate warming, causing substantial transformations in sea ice conditions and ocean circulation with severe consequences for the Filchner Ronne Ice Shelf and the ice streams draining the Antarctic ice sheet. The combination of CTD casts from aboard *Polarstern* and its helicopters together with long-term moorings aims to describe the present physical environment, and monitor its variability and the changes which might occur.

General objectives:

- Which physical properties are the basis to convert the Filchner Outflow region into a hot spot in terms of food availability and as foraging ground for southern elephant seals and likely other seal species?
- Why is this area so unique compared to other places?
- What are the physical properties which control the Filchner Trough in/outflow?
- How can we specify the temporal and spatial variability of the physical properties?
- Is it possible to provide a comprehensive dataset for numerical model validation and initialization of coupled ocean ice shelf - ice sheet models?

Specific objectives:

- How much ISW / (basal) glacial melt water is formed from the Filchner Ice Shelf and how much leaves the Filcher Trough or is available for WSBW formation west of the Filchner Sill?
- How much AABW (WSBW and subsequently WSDW) is generated?
- How can we determine the course of the coastal current in the southeastern Weddell Sea and MWDW flowing towards the Filchner Ice Shelf Front?
- Are we able to specify the path of HSSW from the Berkner Shelf into the Filchner Trough?
- What are the basal melt rates underneath Filchner Ronne Ice Shelf?
- How do these numbers differ by comparing actual and historic observations / data i.e. assess temporal variability, and can that variability be linked to decadal variation or climate change?
- What are the dominant oceanographic features under the sea ice particularly in wintertime when no other data are available due to ship based observations?

Recent investigations in the migratory and foraging behaviour of southern elephant seals yielded data on extended residence times of the seals of up to three months both in summer and winter in the area of the Filchner Outflow. Here the outflow of ice shelf water of the Filchner Ronne Ice Shelf interacts with warm deep water of the Weddell Gyre Circulation. This interaction is supposed to be the primary cause converting this area into a biological "hot spot" where upper and intermediate trophic level interactions maximize. Physical, biogeochemical and ecological studies in the target area shall characterize this biological "hot spot" in detail. As a key area for the formation of Weddell Sea Deep and Bottom Water, the Filchner Outflow on the southern Weddell Sea shelf is of major importance for the global ocean circulation. Even though it is probably the only permanent source supplying ice shelf water for the conversion of surface water into bottom water, the long term variation and production rates of the outflow are unknown.

More recent results from IPCC-scenario simulations with the regional coupled ice-ocean model BRIOS reveal a pronounced sensitivity of the southeastern Weddell Sea to projected atmospheric changes due to climate warming. The complex interplay between different polar processes causes the coastal current to depart from its present course along the continental shelf break and flow into the Filchner Trough. Depending on the strength of the pulses, Warm Deep Water is transported southward to the deep grounding lines of the Filchner Ronne Ice Shelf. The drastic warming of the ice shelf cavern causes enhanced melting at the ice shelf base with possible consequences (subject to ongoing research) for the dynamics of the ice streams draining the West/East Antarctic Ice Sheets and thus for the evolution of global sea level rise. The few hydrographic observations from the southeastern Weddell Sea show that already today Modified Warm Deep Water reaches the front of the Filchner Ice Shelf. However, due to the sparse resolution in time it remains speculative whether this is a permanent feature with constant characteristics (T, S) or a quite variable one.

Enhanced basal melting directly influences the shelf water density on the southern and western Weddell Sea continental shelf, including Ice Shelf Water (ISW). The processes at the sill of the Filchner Trough and along the western continental shelf break are important for deep and bottom water formation and thus for the ventilation of the world ocean abyss. However, the long-term water mass formation rate, its variability as well as its sensitivity to changes in the environmental conditions, including sea ice, remains unclear.

The proposed hydrographic observations in the Filchner Trough are closely related to planned glaciological field work on the Filchner Ice Shelf. The latter is designed to extend existing data sets, necessary for modelling the coupled ice shelf - ice sheet dynamics, and to build-up a reference data set for the expected changes within the ice shelf and ice sheet due to a warming ocean.

We found that the formation of bottom water in the southern Weddell Sea is strongly influenced by the flow of Ice Shelf Water (ISW) out of the Filchner Ronne Ice Shelf cavity. The breakout of three giant icebergs in 1986 and their grounding on the shallow Berkner Bank modified the circulation and water mass formation in the Filchner Trough and the adjacent sea areas (Grosfeldt et al., 2001). Own hydrographic measurements along the Filchner Ice Shelf front, carried out with RV *Polarstern* in 1995, show significant changes in the water mass characteristics and flow patterns in the Filchner Trough in comparison to measurements from the early 1980s (Fig. 3). Changes in the trough will affect the flow over the sill to the deep Weddell Abyssal Plain. We combine a three-dimensional ocean circulation model with conductivity-temperature-depth and stable isotope measurements to investigate the details of the circulation in front of and beneath the Filchner Ice Shelf. We assess the impact of stranded icebergs and a more southerly ice shelf front position caused by an iceberg calving event in 1986 on the circulation and observed water mass properties. Results indicate variations of the flow pattern in the Filchner Trough and on Berkner Bank, where High Salinity Shelf Water, the feedstock for ISW, is produced. The calving and grounding impacts illustrate the sensitivity of the ice shelf–ocean system to perturbations in local bathymetric settings (Grosfeldt et al., 2001).

Cold shelf waters flowing out of the Filchner Depression in the southern Weddell Sea make a significant contribution to the production of Weddell Sea Bottom Water (WSBW), a precursor to Antarctic Bottom Water (AABW). All available current meter records from the region were used to calculate the flux of cold water (< -1.9°C) over the sill at the northern end of the Filchner Depression (1.6 ± 0.5 Sv), and to determine its fate. The estimated fluxes and mixing rates imply a rate of WSBW formation (referenced to -0.8°C) of 4.3 ± 1.4 Sv (Foldvik et al., 2004). We identified three pathways for the cold shelf waters to enter the deep Weddell Sea Circulation. One path involves flow constrained to follow the shelf break. The other two paths are down the continental slope, resulting from the cold dense water being steered northward by prominent ridges that cross the continental slope near 36°W and 37°W. Mooring data indicate that the deep plumes can retain their core characteristics to depths greater than 2,000 m. Probably aided by thermobaricity, the plume water at this depth can flow at a speed approaching 1 m s-1, implying that the flow is occasionally supercritical. It is postulated that such super criticality acts to limit mixing between the plume and its environment. The transition from supercritical to slower, more uniform flow is associated with very efficient mixing, probably as a result of hydraulic jumps (Foldvik et al., 2004).

Work at sea

After transit to the target area, sampling surveys will be carried out with the CTD/water bottle system. A minimum of 90 ship based CTD casts, and another 30 helicopter based CTD casts will be necessary to survey this area. To assess the WSBW formation rates and basal melt rates, we will use CTD and water samples for T, S, nutrients, oxygen, stable noble gas isotopes (to determine the amount of glacial melt water), and transient CFCs (residence time scales of water in the ice shelf cavities and transport time scales in and in front of the Filchner Trough and the slope). It is necessary to have stations/transects along and normal to the Filchner Trough and the assumed down-slope-cascading of outflowing ISW/WSBW. The total station time of this proposal amounts to approximately 14 days (helicopter operations are not expected to consume relevant ship time).

In cooperation with BAS (British Antarctic Survey) and the Bjerknes Centre in Bergen (Norway) it is planned to deploy three additional moorings, aimed to measure both the southward flowing MWDW and the northward flowing ISW on the eastern flank of the Filchner Trough. These moorings will provide the seasonal variation of both water masses over a time span of 2 to 8 years.

Data management

Soon after the end of the expedition a final calibration of hydrographic data will be done. The helium and CFC analysis will be carried out in the Bremen labs. As performed after previous expeditions these data will be fed into data bases such as PANGAEA or send to the German Oceanographic Data Center (DOD), where it is available for the whole international community. PANGAEA guaranties long term storage of the data in consistent formats and provides open access to data after publication.

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2.3.2 Observation of stable noble gas isotopes (^{3}He, ^{4}He, Ne) and transient anthropogenic tracers (chlorofluorocarbons, CFCs)

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Objectives and methods

Useful tools to identify glacial melt water or Ice Shelf Water are the low-solubility noble gases helium (He) and neon (Ne). Atmospheric air with a constant composition of these noble gases is trapped in the ice matrix during formation of the meteoric ice. Due to the enhanced hydrostatic pressure at the base, these inert gases are completely dissolved in the water, when the shelf ice is melting from below. This leads to an excess of Δ^4He=1060 % and ΔNe=770 % in pure glacial melt water (Δ stands for excess over an air-water solubility equilibrium). With an accuracy of 0.5 % for ^4He measurements, melt water fractions of 0.05 % are detectable by this method.

Particularly at mid-ocean ridges in the Pacific, additional (primordial) ^3He (and less ^4He) is released into the deep water, resulting in an enhanced $^3He/^4He$ ratio of about 8 times the atmospheric ratio. These waters contribute to Circumpolar Deep Water, and hence to Warm Deep Water, which then has a maximum $^3He/^4He$ ratio. Neon provides complementary information, since, in contrast to helium, it has no internal sources other than glacial melt water. Combination of these tracers, together with potential temperature and salinity, allow applying a multi-parametric water mass analysis to quantify the source water composition of the observed water masses. This enables us in particular to assess the quantitative spatial distribution of the contribution of glacial melt water, the location, the paths and rates of basal melt water induced bottom water formation and basal melt water rates.

Since the $^3He/^4He$ ratio of the ocean surface is usually in equilibrium with the atmospheric one, observed mixed layer dis-equilibriums can be inferred to assess upwelling velocities and rates from water from below.

Chlorofluorocarbons (here CFC-11 and CFC-12) are gaseous, anthropogenic tracers that enter the ocean mixed layer by gas exchange with the atmosphere. The evolution of these transient or age tracers in the ocean interior is determined by their temporal evolution in the atmosphere and subsequently by advection and mixing processes in deep and bottom water (deep and bottom water formation). They allow estimating transit times of recently ventilated waters in the ocean interior, depicting the ventilation or renewal time scales of these water masses.

Work at sea

We intend to obtain about 600 water samples for noble gas isotopes and 1,000 water samples for CFCs from the ship deployed full depth profiling CTD and water sample system. Additionally, we are going to take water samples for noble gas isotopes from the helicopter deployed CTD system. As the water sample capability of this system is limited, we will only take 2-3 samples from near the bottom and the surface.

The water samples for the noble gas isotopes are drawn from the CTD water sample systems and will be stored in gas tight copper tubes. The samples will be analysed later in the IUP Bremen mass spectrometry lab. After gas extraction, the samples will be analyzed with a special sector field and quadrupole mass spectrometer system. Additionally, we will take water samples with a new developed system, in which previously evacuated glass ampoules are filled half with sea water and then are flame sealed. The advantage of that new system is that no further gas extraction in the home lab is needed, but the noble gases expanded into the headspace of the glass ampoules can be measured directly with the mass spectrometric system.

Water samples for CFC measurements will be stored from the ship deployed water samplers into glass ampoules and will be sealed off after a CFC free headspace of pure nitrogen has been applied. In the IUP Bremen CFC lab the measurement uses a purge and trap sample pre-treatment followed by gas chromatographic (GC) separation on a capillary column and electron capture detection (ECD).

Data policy and storage

Due to the long shipping period for returning home, the extensive treatment of the samples in the IUP home labs, and an accurate quality control, the results of the measurements are expected by the end of 2014 or early 2015. The data will be made available to our colleagues as soon as possible. Once published, we will store them in the PANGEA data base.

2.3.3 Sea ice physics

S. Schwegmann (AWI), G. Castellani (AWI)

Objectives

The mass- and energy balance of sea ice and its snow cover are key elements for a better understanding of the interaction between atmosphere, ice and ocean of the Southern Ocean. Although satellite observations allow to survey the extent of sea ice around Antarctica on a daily basis, it is not yet understood which are the main drivers for the large regional differences. The trend of the mean annual sea ice extent differs strongly in thickness and direction for different regions. For the Weddell Sea, a positive, but not significant trend towards larger extents has been derived over the last decades.

Therefore, it is of particular interest to gather *in-situ* observations covering the spatial variability and seasonal evolution of the physical properties of snow and sea ice. The planned measurements will benefit from the design of the *Polarstern* expedition ANT-XXIX/9, entering deep into the Weddell Sea. At the same time, the sea ice physics work will extend similar work during the winter experiments (ANT-XXIX/6 & 7). These data are crucial, because they cover different seasons and regions of the Weddell Sea. For example, we will deploy buoys in the same region as during ANT-XXIX/6, but half a year later. Hence, the drift of these buoys will add similar observations, but during different times of the year. Other deployments further into the Weddell Sea are seldom possible and will result in unique data from the central Weddell Sea. Furthermore, to investigate the interaction of sea ice and ice shelves, data and sea ice samples from sea ice regions close to ice shelves are needed. The contribution of platelet ice (ice crystals formed deeper into the ocean and adding to sea ice mass balance) can best be studied close to ice shelves, such as Filchner Ice Shelf. These observations complement ongoing studies at Atka Bay (Neumayer III base) and during the winter experiments.

The gathered data sets will also serve as a valuable tool for the validation of satellite-based (e.g. CryoSat-2, SMOS) and simulated sea ice thickness distributions. Buoy data will also contribute to the International Program on Antarctic Buoys.

Work at sea

In order to obtain such data with greatest efficiency in terms of personnel and ship/helicopter time, autonomous observatories (buoys) will be deployed and along-track sea ice observations will be performed. In addition, some sea ice cores will be extracted for more insights into physical properties of sea ice. The work will be in close collaboration with the IceFlux Group (H. Flores) and the oceanography group (M. Schröder).

A combination of sea ice mass balance and snow depth buoys will be deployed along the cruise track on three positions. These buoys will measure and transmit various snow and sea ice properties and complement identical deployments in the Weddell Sea during ANT-XXIX/6. The buoy deployment will be performed by helicopter with short flights off *Polarstern* onto selected floes. In addition to the deployment some basic snow and sea ice observations will be performed. The buoys are an integrative part of the Autonomous Bio-Physical Sea Ice Observatory (ABiPSO, H. Flores).

Continuous visual observations of the sea ice cover and meteorological conditions will be made on an hourly basis from the ship's bridge by trained observers. Observed parameters include sea ice concentration, concentration and thickness of different sea ice types, thicknesses and type of snow cover. These observations follow a standard protocol and contribute to the international ASPeCt data base. Identical observations are also performed during the earlier legs.

Sea ice cores will be drilled on selected floes. These floes can be accessed by helicopter, e.g. combined with buoy deployments, or directly from the vessel during station times.

Data policy

Sea ice thickness and snow depth data, physical properties of snow and sea ice, and sea ice observations will be post-processed and delivered to PANGAEA within two years after the cruise. All autonomous data from drifting buoys will be available through different project home pages. Buoy positions and atmospheric parameters will be presented online and in real time as part of the new data and information portal for sea ice (www.meereisportal.de). Archive cores from all ice stations will be archived in the cold storage facilities of the Alfred Wegener Institute.

2.4. BIOLOGY AND BIOGEOCHEMISTRY (HOTFOS)

2.4.1 Pelagic roductivity at the Filchner Trough in the southern Weddell Sea

H. Auel (UHB-MarZoo), J. Dürschlag (UHB-MarZoo)

Objectives

Filchner Trough in the high Antarctic southern Weddell Sea apparently is a biological hot-spot. For instance, elephant seals regularly migrate from their breeding and moulting grounds on sub-Antarctic islands to this region for feeding. In general, seals are opportunistic feeders, gathering in highly productive regions that provide sufficient prey and favourable feeding conditions. This raises the question why food supply and productivity in the sea ice covered high Antarctic area of the Filchner Trough should be higher than in other regions at comparable latitude. In close cooperation with other research teams on board, BreMarE, the Bremen Marine Ecology Centre tackles the question what are the ecological mechanisms and/or physical-biological interactions that make Filchner Trough a biological hotspot in the high-Antarctic southern Weddell Sea. In this context, BreMarE's focus will be on quantifying the pelagic primary and secondary productivity of phytoplankton, ice algae, and zooplankton. In addition, studies will also include the adaptability and sensitivity of key species within the food web to changes in abiotic conditions.

The project will address and test the following hypotheses:

1) Locally enhanced primary production by phytoplankton and/or ice algae provides a broader base for the food web and, hence, more food for zooplankton, which in turn increases food availability for fish and upper trophic levels.

Increased nutrient availability, for instance by advection or water-mass mixing, or better light conditions, for example by ice-free polynyas, could trigger an enhanced primary production. To test this hypothesis, phytoplankton and ice-algal biomass (chlorophyll a content) will be measured at the Filchner Trough and compared to adjacent regions in order to establish whether they are indeed higher.

2) In the region of the Filchner Trough, the energy transfer along the food chain is more efficient than in other parts of the Weddell Sea. A more efficient energy transfer would lead to

surplus energy for upper trophic levels, although primary production could be equal to reference sites.

The efficiency of energy transfer within food webs critically depends on the number of trophic steps, i.e. predator-prey relationships, in the food chains and the feeding strategies of the different components of the food web. Since the transfer efficiency from one trophic level to the next one usually is only between 10 to 20 %, the longer a food chain is, the lower is the amount of energy (i.e. the food supply) available for upper trophic levels. In addition, pelagic food webs that are dominated by opportunistic, filter-feeding species tend to be more efficient in energy transfer than more complex communities characterised by food specialists. Filter feeders can efficiently utilise a wide spectrum of prey size classes and therefore severely reduce the feeding opportunities for competing specialists. The most famous example, which combines both effects, is the short, three-step food chain prevailing in certain parts of the Antarctic seasonal sea ice zone and including diatoms, Antarctic krill *Euphausia superba* and baleen whales, the latter two being very efficient filter-feeders.

In principal, high Antarctic food chains south of the distribution range of *E. superba* and most baleen whale species should be less efficient. However, the ice krill *Euphausia crystallorophias* does occur in the southern Weddell Sea, and other key components of the marine food web, such as *Pleuragramma antarcticum* and squid, may affect the efficiency of energy transfer. In addition, certain eco-physiological adaptations of high Antarctic species, for instance specific energy-saving overwintering strategies and diapause in the dominant copepod *Calanoides acutus*, may reduce metabolic activity and energy costs and, hence, increase the transfer efficiency of energy throughout the food web.

The energy pathways throughout the food web at Filchner Trough will be traced by trophic biomarker studies (fatty acid trophic biomarkers, $\delta^{13}C$ and $\delta^{15}N$ stable isotopes) to identify predator-prey relationships. In addition, the metabolic activities of key zooplankton species will be measured by state-of-the-art optode respirometry. This methodology will also allow calculating the food requirements of the different populations based on biomass data and an energy budget approach linking respiration rates to actual ingestion.

Work at Sea

Sampling

During ca. 50 stations in the region of the Filchner Trough and at adjacent reference sites, a regular sampling programme will be carried out with CTD/rosette casts to record hydrographical parameters and to collect water samples for chlorophyll a and phytoplankton analyses. Zooplankton will be sampled by stratified multiple opening/closing net hauls (Hydrobios Multinet Midi or Maxi) from the seafloor to the ocean surface. Zooplankton samples will be sorted immediately after the catch in temperature-controlled rooms onboard. Specimens of the dominant taxa will be used for respiration measurements onboard or deep-frozen at -80°C for later biochemical analyses (lipid content, lipid class composition of storage lipids, fatty acid biomarkers, stable isotopes, digestive enzyme activities) in the home lab at Bremen University.

Phytoplankton and ice-algal biomass and primary production

In order to study the availability of phytoplankton as principal food source, chlorophyll *a* concentrations will be measured according to standard procedures. In addition, phytoplankton samples will be collected for taxonomic analysis by Utermöhl microscopy. In cooperation with other research teams on board, the biomass of ice algae will be measured by drilling sea ice cores, cutting them into slices, melting the slices under controlled conditions in filtered seawater and measuring the chlorophyll a concentration. Again, parallel samples will be collected for microscopic analysis. In addition, primary production will be measured experimentally via the production of oxygen and optode oxygen sensors.

Respiration measurements onboard

Respiration of key zooplankton species will be measured non-invasively by optode respirometry with a 10-channel oxygen respirometer (Oxy-10 Mini, PreSens Precision Sensing GmbH, Regensburg, Germany) connected to a laptop computer. Oxygen-sensitive sensor spots are glued to the inner walls of 10 gas-tight glass bottles. Bottles will be filled with oxygenated seawater, filtered through 0.2 µm Whatman GFF filters to exclude microbial activity. Depending on body size, incubation bottles will contain 1 to 5 individuals. Experiments will be run under simulated *in-situ* conditions in temperature-controlled incubators on board within water-baths to ensure constant thermal conditions throughout the experiments. For each experimental setup, two animal-free control bottles will be incubated under exactly the same conditions to compensate for microbial respiration. After the termination of the experiments, specimens will be deep-frozen at -80°C for the determination of body mass in the home laboratory. Respiration rates will be calculated by determining the slope of the decrease in oxygen concentration over time taken into account the development of the animal-free controls. The first 60 min of each experiment will be ignored to exclude potential temperature effects and handling stress of the animals.

Quantification of ingestion rates and energy demands

For the estimation of energy requirements of key zooplankton species and trophic carbon fluxes throughout the marine food web, individual oxygen consumption rates will be converted to carbon units. Individual ingestion rates can then be calculated according to an energy budget approach. In order to assess the food intake of dominant species at the population level and to evaluate their impact on the carbon flux in the Filchner Trough vs. adjacent reference sites, ingestion rates of these populations will be estimated based on individual ingestion rates and abundance data for the respective species in the different habitats. In addition, secondary production of copepods can be measured directly according to the standard egg production rate method.

Dietary spectra of key species

In order to establish the dietary spectra of dominant zooplankton species, state-of-the-art trophic biomarker approaches will be applied including fatty acids and stable isotopes ($\delta^{15}N$, $\delta^{13}C$). Although trophic biomarker analyses have a lower taxonomic resolution than classic gut-content analysis (i.e. only specific taxa may be distinguished through certain taxon-specific chemical compounds), they integrate trophic signals over longer time spans of several weeks to months. Fatty acid compositions will be evaluated following the trophic biomarker concept. 16:1(n-7), as well as 16:4(n-1) and 18:1(n-7) are used as indicators of a diatom-dominated diet. 18:4(n-3) is applied as (dino-)flagellate marker. The ratio 18:1(n-9)/18:1(n-7) will be calculated to estimate the degree of carnivory versus herbivory. In addition, the fatty acid ratio of [18:1(n-9) + 20:1(n-9) + 22:1 (n-11)]/[16:1(n-7) + 16:4(n-1) + 18:1(n-7) + 18:4(n-3)] will be applied as a more robust relative measure of carnivory.

For stable isotope analysis, dried samples of zooplankton will be transferred to tin capsules and stable isotope analyses will be performed by TÜV Rheinland Agroisolab in Jülich, Germany, using a mass spectrometer (EA NA1500 Series 2, Carlo Erba Instruments) and helium as carrier gas. Small zooplankton organisms can be measured as whole animals (dry mass between 0.5 and 7.0 mg); for larger organisms only parts of their muscles, liver, or caudal fins will be taken. Determination of carbon and nitrogen stable isotope ratios will be conducted using the standards IAEA-VPDB (IAEA-C1) and atmospheric air (IAEA-N1), respectively. Comparative data from other parts of the Weddell Sea are available from previous expeditions.

Data management

Data to be obtained during the expedition cruise will form part of a M.Sc. thesis at Bremen University. It is expected that all essential data will be published and made available in web-based data bases, such as PANGAEA, within two to three years after the expedition. Depending on the speed of the different analyses, certain data sets will be available earlier, soon after the publication of the respective scientific articles.

2.4.2 Pelagic macrofauna and bio-physical sea ice properties

H. Flores (AWI, not on board), B. Lange (AWI), D. Kohlbach (AWI), M. Vortkamp (AWI)

Objectives

Pelagic food webs in the Antarctic sea ice zone can depend significantly on carbon produced by ice-associated microalgae. Future changes in Antarctic sea ice habitats will affect sea ice primary production and habitat structure, with unknown consequences for the Antarctic ecosystems. Antarctic krill *Euphausia superba* and other species feeding in the ice-water interface layer may play a key role in transferring carbon from sea ice into the pelagic food web, up to the trophic level of birds and mammals (Flores et al. 2011, 2012). Besides Antarctic krill, deep-dwelling pelagic fish such as the lanternfish *Electrona antarctica* can be very important in the energy budget of the ecosystem (Flores et al. 2008). The trophic connection of the deeper-dwelling pelagic fauna with sea ice carbon sources, however, is practically unknown. To better understand potential impacts of changing sea ice habitats for Antarctic ecosystems, the HGF Young Investigators Group *Iceflux* aims to quantify the trophic carbon flux from sea ice into the pelagic food web. This will be achieved by 1) quantitative sampling of the pelagic and under-ice communities and environmental parameters; 2) using molecular and isotopic biomarkers to trace sea ice-derived carbon in pelagic food webs; and 3) applying sea ice-ocean models to project the flux of sea ice-derived carbon into the under-ice community in space and time. ANT-XXIX/9 provides the opportunity to quantify the pelagic macrofauna (zooplankton and micronekton) in a seldom visited ecological hotspot of the Antarctic sea ice system, and to link pelagic macrofauna abundance to sea ice-derived carbon flux obtained from biomarker analysis. In addition, the dominant sea ice drift in the target area of this expedition offers the possibility to sample the change of biological and physical sea ice parameters with autonomous buoy arrays in the Weddell Sea over almost a full year-cycle. These measurements include hyperspectral profiles of light transmission through sea ice, which can be used to estimate ice algal biomass (Mundy et al. 2007). This work will be a continuation of studies conducted during ANT-XXIX/6 and 7 and will result in a unique and extensive dataset on the seasonal and regional variability of sea ice ecosystems in the Southern Ocean.

Work at sea

Pelagic sampling

The *Iceflux* team will work closely together with the zooplankton group of the University of Bremen (H. Auel), the ecological chemistry group (B. Koch), and the fish group (R. Knust). We aim to quantify the abundance and species composition, and investigate the horizontal and vertical distribution of pelagic macrofauna, e.g. euphausiids, amphipods, and myctophids. Samples will be collected with a Multiple opening Rectangular Midwater Trawl (M-RMT). If available, M-RMT sampling will be complemented with profiles of *Polarstern's* EK60 echo sounder during steaming. Depth-stratified M-RMT hauls will be conducted whenever possible from the surface down to 1,000 m depth, distributed over a station grid covering the areal extent of other fishing (bentho-pelagic nets) and zooplankton sampling during ANT-XXIX/9. On an opportunistic basis, M-RMT sampling may be complemented with target hauls based on EK-60 or other observations (e.g. top predator foraging behaviour). The samples will be quantitatively stored frozen (-20°C) or on formaldehyde (4 %), if not used otherwise (see below). Our team will further be involved in the sampling of zooplankton with multi nets and bongo nets, as well as sampling *in-situ* chlorophyll concentrations with the CTD rosette. Cephalopods will be sampled on behalf of U. Piatkowski (GEOMAR).

Biomarker analysis

Samples of ecological key species (e.g. euphausiids, amphipods, myctophids) obtained from M-RMTs and other sampling gear will be taken to estimate the importance of sea ice-derived carbon for these organisms using fatty acid and stable isotope biomarkers. The samples will be sorted by species and developmental stage, and subsequently preserved at -80°C. In order to estimate the sea ice signal at the trophic baseline, also samples of sea ice biota (collected with ice corers) and phytoplankton (collected with the CTD rosette) will be concentrated on pre-combusted GF/F filters, and frozen at -80°C. In the home laboratory, coupled gas chromatography and mass spectrometry will be used to determine the lipid, fatty acid and stable isotope composition of the material, as well as the stable isotope fractionation of microalgal marker fatty acids. The latter approach allows distinguishing sea ice-derived from water column-derived fatty acids of taxonomically similar algal communities.

Work on ice floes

Our sea ice work is conducted in close collaboration with the AWI sea ice physics team (S. Schwegmann, M. Nicolaus), Volker Strass (AWI), I. Peeken (AWI), and Klaus Meiners (AAD). On-ice work will consist of ice coring, bio-optical measurements, and the deployment of two Autonomous Bio-Physical Sea ice Observatories (ABiPSO). Ice coring and bio-optical measurements will be done at multiple sites in order to capture the small-scale variability of ice algal biomass and physical properties. On each coring site, cores will be collected for biomarker analysis; chlorophyll *a* content; salinity; temperature and ice texture. The bio-optical measurements are an important prerequisite for the calibration of hyper-spectral light profiles later obtained from ABiPSOs. They require the deployment of an L-arm under the ice with a mounted spectral radiometer to acquire the spectral light properties of the sea ice and the under-ice environment. On L-arm survey sites, ice cores will be extracted and processed for chlorophyll *a* content in order to determine the relationship of ice algal biomass with the under-ice spectral light properties.

We will deploy two ABiPSO stations, each consisting of 4 independent systems: 1) ice mass balance buoy (IMB) measuring ice thickness and temperature, as well as the water temperature down to a depth of 25 m; 2) Bio-optical system consisting of three spectral radiometers to observe light transmission and derived ice algal biomass; 3) MetOcean CTD buoy for under-ice water salinity and temperature; 4) ADCP buoy for water current velocity and direction, and for the estimation of zooplankton vertical distribution from backscatter data. The systems will be deployed on two different ice floes with a high probability of surviving the rest of the melt season based on satellite images, *in-situ* inspection, and drift trajectories.

Data management

Almost all sample processing will be carried out in the home laboratories at AWI. This may take up to three years depending on the parameters as well as analysis methods (chemical measurements and species identifications and quantifications). As soon as the data are available they will be accessible to other cruise participants and research partners on request. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA and SCAR-MarBIN, and will be open for external use.

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2.4.3 Pelagic-benthic processes in the Filchner Outflow area

E. Isla (ICM-CSIC), C. Richter (AWI, not on board), S. Ambroso (ICM-CSIS), J.-M. Gili (ICM-CSIC, not on board), N. Owsianowski (AWI), L. Federwisch (AWI), R. Zapata (ICM-CSIC), P. Casado de Amezúa (AWI, UAH)

Objectives

The marine vicinities of Filchner Ice Shelf have been identified as one of the principal areas of deep and bottom water formation in the southern Weddell Sea, where the outflow of cold and fresh water from below the shelf ice mixes with the oceanic Weddell Sea Gyre waters. The resulting physical fronts presumably convert the region into a biological hotspot. This study area is of great interest for multidisciplinary scientific research given the fact that polar regions are especially sensitive to the ongoing global warming and climate change. Thus, it is easy to imagine that these biological hotspots may be undergoing rapid transformations linked to environmental changes. On this basis, analysing how the productive processes in the pelagic zone couple with the benthic realm offers the possibility to investigate how the actual environmental conditions are reflected in the status of the local benthic communities and the chemical characteristics of the sediment providing a baseline for a region where this information is scarce. We expect to identify how the region reacts to environmental changes and the effect of these reactions on the local biogeochemical cycles, especially those of the carbon and silicon, and the Antarctic biota. We will enrich the expected results of the present project with a comparison with other areas of the Weddell Sea where climate change produced dramatic changes and others where its effects are less evident. The scenario offers unique opportunities to examine to which extent the effects of climate change in Antarctica may determine changes elsewhere in the ocean, specially, on how the influence of ice shelves determine the intensity of biological production in polar areas.

The aim of the present proposal is to identify the characteristics of the pelagic-benthic coupling in the marine vicinities of Filchner Ice Shelf through the analysis of currents; plankton and seston abundance, composition and fluxes; abundance and distribution of benthic communities; function of selected species in carbon and silicon flux; and biochemical characteristics of the sediment. We want to answer questions relative to the transfer of organic matter from the euphotic zone to the benthic realm and how the environmental variables may set conditions for primary production to develop.

Specific questions are:

- is the Filchner outflow area a benthic-pelagic hotspot, i.e. a local enrichment in plankton and benthos relative to surrounding areas? What is the actual status of the diversity, abundance and biomass of the local benthic communities?
- to what extent is the biological enrichment related to particular bathymetric (ridge, canyon) and hydrographic features (vertical currents)?

- which are the magnitude and composition of organic matter and mineral fluxes between the shelf and oceanic, surface and deep areas?
- what are the quality and quantity of the organic matter incorporated into the sediment?
- which are the main species enhancing pelagic-benthic coupling in the area?

The main objectives are:

- To determine the spatiotemporal distribution and vertical swimming capacity of zooplankton in relation to vertical currents
- To determine the spatial distribution and biodiversity of the benthic communities, with a focus on sponges and cnidarians (anthozoans, gorgonians)
- To identify their dispersal capacities and genetic variability within and among different populations
- To measure the retention of (pico-) plankton carbon and dissolved silica by the suspension feeder community
- To analyse the distribution of the particulate silicon and organic matter in the sediment column through the analyses of several variables (e.g., protein, lipid, carbohydrates, phytopigments, amino acids, fatty acids and 14C, 210 Pb)
- To identify local characteristics of particle fluxes, currents and organic matter distribution in the sediment column in a short-scale (km) spatial distribution in a highly productive polar setting.

Work at sea

Plankton

A short-term mooring with two upward-looking Acoustic Doppler Current Profilers (ADCP, Teledyne-RDI 150 kHz Quartermaster Sentinel, 340 m range; and 1200 kHz Workhorse Sentinel, 20 m range) and a multisensor CTD (SBE 19plus V2, with oxygen, Chl a, pH sensors) will be deployed near the shelf break to record the small scale variability in horizontal and vertical currents. To correct for plankton swimming against the vertical flow, where the ADCP is likely to underestimate flow speeds due to the compensatory movement of the backscattering plankton, an ADV will be mounted. The very high frequency (10 MHz) will ensure that small plankton with negligible swimming speeds will be recorded, while larger potentially swimming zooplankton will be missed out. Quantifying plankton enrichment in downwelling flows will require new methodology: A novel ROV-mounted light-sheet illuminating a defined volume of water in a defined distance to the ROV camera will allow to quantify the abundance, size distribution and motion of particles flowing parallel to the light-sheet (perpendicular to the camera axis). By simultaneously using a large (30 x 20 x 3 cm) and a small (10 x 5 x 1 cm) light sheet in front of the two ROV HD cameras, the differential motion of different sized plankton can be observed. Plankton attraction by light will be avoided by the use of a red filter. Swarming plankton, krill and fish as well as squid will be detected using the ROV's sonar. Plankton motion near the sea bed will be measured with the ROV in parking position. Water column video data will be ground-truthed with plankton material caught by nets (Multinet, in cooperation with Auel et al.; RMT, in cooperation with Flores et al.). Capture rates by tentaculate planktivores will be recorded by placing the light sheet across a tentacle crown, following the plankton trajectories and recording the hits and misses. Picoplankton will be sampled by a novel sipper system mounted on the ROV, where a revolver system of spring-loaded syringes allows the collection of up to twenty 20 ml syringe water samples per dive in the benthic boundary layer and near sponges. Samples will be analysed immediately on board or will be fixed with glutaraldehyde, snap-frozen in liquid nitrogen and stored at -80°C until analysis.

Benthos

The ROV twin HD video cameras will be used to map the composition and distribution of the benthos down to the maximum range of 500 m. For the deeper benthos, OFOS transects will be carried out. 3D-modelling will be used to convert 2-D video data to biovolume and biomass, using mass-length relationships (both known and t.b.d.) of the main constituents (e.g. sponges). Ground-truthing will be done by Agassiz and benthic trawls providing sample material for representative benthic groups (e.g., cnidarians, molluscs, sponges, ascidians). Gorgonians will be sorted and identified on board. For biodiversity studies, dispersal capacities and genetic variability within and among different populations of known gorgonians, a sub sample of tissue will be fixed with 96 % ethanol, photographed and sub sampled with taxonomical purposes. A minimum of 10 individuals will be collected for each station. Specimens will be frozen in liquid nitrogen or kept at -80ºC and also some fragments will be kept in ethanol 100 % and RNA ladder for molecular (DNA and RNA) analysis at the ICM-CSIC for population genetics studies in order to identify clones within and among populations to determine the structure and dynamics of the gorgonian populations in different regions.

Non-invasive methods such as video recording will be used to compare gorgonian species composition and richness taking into account the different environmental characteristics in the water column over a large geographic and bathymetrical extent, to analyse their size structure and to assess the possible ecological relationships between abundance and colony size and sea floor features.

Iceberg disturbance severely disrupts large areas of the seafloor in the shallower parts of the Antarctic shelf, affecting the physical and biological environment by removing the substratum and eradicating benthic life. To better understand this phenomenon we also want to investigate the potential influence of iceberg scouring on the spatial distribution of the main benthic communities with the aid of the ROV imagery. A transponder system tracklink will record the positions of the ROV allowing georeferencing the location of the video transects in a bathymetric map.

The ROV will also be used to map the hanging benthos beneath the ice shelf, if opportunity arises. It will also be available for fine-scale studies under pack ice (cooperation with H. Flores).

Sediment

A sediment core grid will be set covering the vicinities of the Filcher outflow path and the Filchner depression. In addition some stations in the BENDEX area will be revisited to assess changes in organic matter distribution since the last sampling effort in 2011. Sediment cores will be recovered with a multibox corer or a MUC, depending on the grain size and sea floor characteristics. Sediment cores will be subsampled on board in slices 0.5 cm to 2 cm thick. A conical SMT 234 sediment trap will be moored 20 m above the seabed (mas) coupled to a current meter Aanderaa RCM9 located 8 mas. Operating time of these instruments will be decided on board.

Data management

All the data generated from this expedition will be included both in Pangaea and in the Spanish Polar Database located in the Spanish Polar Committee's National Polar Data Center, http://hielo.igme.es/index.php/en/.

2.4.4 Molecular biogeochemical provinces in the Southern Weddell Sea

K. Ksionzek (AWI), D. Janssen (AWI),
M. Graeve (AWI, not on board), B. Koch (AWI, not on board)

Objectives

It has been suggested that the Filchner Outflow is a biological “hotspot” where upper and intermediate trophic level interactions maximize. The region is oceanographically characterized by the outflow of ice shelf water of the Filchner Ronne Ice Shelf which interacts with warm deep water of the Weddell Gyre circulation. Biogeochemical studies in the target area will extend our recent approach of molecular biogeochemical provinces (Koch et al., 2011) and characterize this biological "hotspot" in detail. As a key area for the formation of Weddell Sea Deep and Bottom Water (WSDW and WSBW), the Filchner Outflow on the southern Weddell Sea shelf is of major importance for the global ocean circulation. Even though it is probably the only permanent source supplying ice shelf water for the conversion of surface water into bottom water, the long term variation and production rates of the outflow are unknown.

Bottom water formation in the Weddell Sea is also an important potential mechanism which transports sea ice algae-derived dissolved organic matter (DOM) from the photic zone into the deep sea. This mechanism might contribute substantially to the ocean organic carbon flux and the transport of organic nutrients. Primary production in sea ice is likely a prime source of this organic material. The molecular composition of organic matter is a key to estimate bioavailability. It also can provide a chemical fingerprint for a specific source or process. Despite recent substantial progress in the field of molecular characterization of marine DOM (e.g. Flerus et al., 2012; Koch et al., 2005), namely by the application of Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR-MS), the chemical nature of dissolved organic sulphur (DOS) remains largely unknown. To improve our understanding of the role of heteroatomic organic matter in cryo-pelagic and bentho-pelagic processes (e.g. nutrient cycling; methanogenesis), we will analyze bottom water samples and sediment pore water samples using high performance liquid chromatography hyphenated to inductively coupled plasma mass spectrometry (HPLC-ICP-MS; Lechtenfeld et al., 2011). A special focus will be on the relation of the molecular changes as a response to different oxygen concentrations.

Our goal is to achieve a high spatial resolution data set, specifically in surface and bottom water of the southern Weddell Sea, in order to improve our mechanistic understanding of the biogeochemistry of DOM. Specific research hypotheses of this study are:

- The biological hotspot at the Filchner Ronne Ice Shelf can ultimately be explained by the occurrence of a specific biogeochemical province characterized by organic matter quantity and quality and inorganic nutrient availability.
- Sea ice derived molecular fingerprints can be detected in bottom water of the southern Weddell Sea.
- The apparent oxygen utilization controls organic sulfur speciation in the water column below the sea ice and at the sediment-water interface.

Work on board

The work on board is tightly coordinated with the groups led by M. Schröder / H. Bornemann, H. Auel, and H. Flores. Water samples will be taken on all CTD stations with a special focus on the uppermost and lowermost water column. Samples from the Filchner Outflow will be collected from profiles with high depth resolution in the upper 200 m. In addition, we seek to sample the down-slope-cascading of outflowing Ice Shelf Water/Weddell Sea Bottom Water (ISW/WSBW).

On few selected stations, sediment pore water and the overlying water column will be sampled and pore water will be extracted using rhizon samplers.

All samples will be filtered through precombusted GF/F filters and preserved for subsequent analyses of inorganic nutrients and dissolved organic carbon (DOC) and nitrogen (DON) back in the AWI laboratory in Bremerhaven. Selected samples will also be analysed for dissolved amino acids. Solid phase extraction (SPE) and liquid-liquid extraction of DOM from filtered water will be performed on board. Quantitative information on DOS and DOP in the extracted samples will be derived by HPLC-ICP-MS and related to compositional FT-ICR-MS information.

Data management

Ship based data as well as analytical data generated in the laboratory in Bremerhaven will first be processed in an internal access database. After further analytical and/or statistical evaluation, e. g. multivariate statistics, data will be provided for publication in the open access information system PANGAEA (http://www.pangaea.de/).

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2.4.5 Benthos communities and production

D. Gerdes (AWI), S. Pineda (AWI, UMAG), H. Bohlmann (ISITEC), R.Steinmetz (AWI)

Objectives

Heavy ice conditions year round make the southern Weddell Sea and particularly the Filchner Trench to a rarely visited and poorly sampled high Antarctic region. Valuable data from the Filchner Trench date back to the early studies of Voss (1988), who described the shelf fauna between Atka Bay in the northeast to the base of the Peninsula in the southwest based on Agassiz Trawl and bottom trawl catches. According to this study a ´Southern Trench Community´ is living on the soft bottoms with scattered erratic boulders and stones in the Filchner Trench. This community type seems to differ distinctly from the biomass rich and diverse suspension feeder dominated shelf community on the eastern Weddell Sea Shelf. Up to now just 2 stations had been sampled in the Filchner Trench with quantitative corers, positioned directly at the southernmost edge of the Filchner shelf ice, i.e. at present the Filchner Trench appears as a gap between our benthic studies that focussed more on the north eastern Weddell Sea shelf and the Peninsula region.

The planned work aims to get quantitative samples from the Filchner Trench in order to analyse the composition, organism densities and biomass as well as production of benthic stocks in this rarely studied part of the Weddell Sea.

Work at sea

To answer the principal questions mentioned above the multibox corer equipped with an UW camera system will be deployed at 17 stations. The planned station grid contains stations from directly in front of the ice shelf edge to the slope of the trench in the north and with an east to western extension from 29° to 42° west, i.e. the borders of the eastern shelf community and the southern shelf community are included, although the bulk of stations are situated directly in the Filchner Trench in order to allow a proper description of the so far unstudied region. The positions of the stations were chosen taking older benthos studies as well as the planned oceanographic studies into consideration, and to allow an analysis of the entire area of the Filchner Trench including the slope to the deeper parts of the Weddell Sea.

Data management

All data generated from this expedition will be published in the AWI data base PANGAEA (http://www.pangaea.de/).

2.4.6 The BENDEX Experiment: Follow-Up 2

D. Gerdes (AWI), R. Knust (AWI), H. Bohlmann (ISITEC)

Objectives

Iceberg scours inflict substantial damage on established communities of endo- and epifauna. In the course of recovery it is possible to distinguish different successional stages of recolonization although it has never been possible before to place those stages in an absolute temporal sequence. As iceberg scouring destroys older and major community stages, it creates space for ´pioneer species´ which initiate recolonization. Various hypotheses in the literature have attempted to describe the effects of such processes on biodiversity. As a general result an enhancement of diversity on larger scales appears due to the co-existence of a variety of recolonization stages with different species inventories. Beside this effect on biodiversity, the time scale of recovery after disturbance is considered to be an important question, because in comparison with community recovery in lower latitudes it illustrates the vulnerability and resilience capacity of polar systems.

To set a time stamp for recolonization an artificial mechanical disturbance experiment was started in 2003 to simulate the impact of grounding icebergs on benthic and demersal fish communities. As a result benthic biomass was drastically reduced by a factor of 10. In 2011 we revisited the BENDEX site to follow the recolonization and succession in the disturbed area. The multibox corer was deployed on 8 stations in the BENDEX site and 4 stations adjacent to this area. At that time the BENDEX area still hardly showed any signs of recolonization. Eight years after the disturbance inside the BENDEX area clear trials of the fishing gear were visible, whereas epifauna was rare or totally absent. In between the gear marks the trawl activities had accumulated locally benthic material, on which living specimens of sponges, ascidians and especially motile taxa such as brittlestars, crinoids, and seastars. Just on 2 marginal stations in the experimental site (St. Nos. 289 and 293) the MG collected 1-3 cm juvenile, max. 3 yrs old specimens of the demosponge Tethyopsis cf. longispinus, which were assumed to be the first pioneer species inside the BENDEX area. These studies will be continued in order to get a proper data base which finally allows us for the first time to quantify recolonization and succession processes in high Antarctic benthos after disturbance.

Work at sea

The BENDEX site and some reference stations adjacent will be sampled with the multibox corer, the attached UW camera will provide additional high quality pictures from the seafloor plus benthos. A ROV was already deployed twice on transects crossing the artificially disturbed BENDEX area and it is planned to repeat this transect again in order to compare the recolonization process of the benthos from 2003, 2011 and now 2013/4.

Data management

After data calculations, all results generated from this expedition will be published in the AWI data base PANGAEA (http://www.pangaea.de/).

2.4.7 Reconstructing historical connectivity and isolation patterns in extant Weddell Sea macro benthos using molecular techniques

C. Sands (BAS), C. Havermans (AWI, IRSNB), K. Beyer (AWI),
C. Held (AWI, not on board), M. Eléaume (MNHN, not on board)

Outline

The continental Antarctic Shelf features few effective barriers that might impede gene flow and yet recently many species previously believed to be circumpolar were recognized to consist of numerous species with smaller, allopatric distribution areas (e.g. Held 2003; Held & Wägele 2005; Havermans et al. 2011). We hypothesize that effective barriers and pathways existed in the geological past, and that especially the variation of coverage of shelf and sea ice influenced the formation of species in the past.

Due to heavy ice conditions year round, the southern Weddell Sea, and particularly the western extreme, is rarely visited, poorly sampled, and yet biologically intriguing. It is unknown if the benthic assemblage is similar to that of better sampled adjacent regions, for example, the BENDEX area. There is shelf connectivity between these regions and the Weddell Gyre promotes a current that is likely to facilitate transport from the BENDEX region, but on the other hand unique morphotypes of ophiuroids and isopods were collected at multiple locations adjacent to the Filchner Ice Shelf, indicating that connectivity may be more restricted than expected. We expect this under-sampled region to harbour an important number of species new to science.

Some attention has recently been focused on a possible seaway between the Weddell, Amundsen and Ross Seas during previous interglacial (Barnes & Hillenbrand 2010).

Objectives

We aim to document and identify portions of the macrobenthic assemblage with a particular emphasis on crustaceans and ophiuroids using both morphological and molecular tools. A DNA barcode library of COI sequences of lysianassoid amphipods has been established earlier and will allow a rapid species identification and detection of undescribed species. Secondly, population genetic, phylogeographic and phylogenetic studies will be carried out on target amphipod taxa, using genetic markers with different evolutionary rates. Phylogeographic and population genetic studies will allow us to uncover cryptic diversity and investigate the spatial genetic structures of taxa characterized by different dispersal capacities. Moreover, by means of phylogenetic analyses, we aim to assess the historical colonization patterns between shallow-water and abyssal species. Since this region represents an important pathway for cold shelf waters to enter the deep Weddell Sea circulation via the formation of the Weddell Sea Bottom Water, its fauna might be tightly linked to that of the adjacent deep-sea basins.

Samples will be used for ecological, population genetic and phylogenetic analyses in order to better understand the origins and persistence of the Antarctic benthos. These samples will add important geographic resolution to phylogeographic studies being conducted.

Work at sea

Our group will collect benthic invertebrates, which will be sampled using the Agassiz trawl and Rauschert dredge. Main target groups include, but not restricted to, crustaceans, ophiuroids, asteroids, crinoids, pycnogonids and molluscs. Baited traps will be used whenever allowed by meteorological conditions and ice coverage. Where possible in certain groups (e.g. amphipods and ophiuroids), samples will be sorted to morphotype, photographed and tissue samples taken for preservation for both RNA and DNA work. The sorting, preparation of samples, photographing and preliminary identifications will be carried out on board. Most of the samples will be fixed in absolute ethanol at –20°C, for further DNA analyses. For selected taxa of interest to our studies, DNA extractions will take place on board. Sequencing of nuclear and mitochondrial markers will take place upon return to the lab at AWI and BAS.

Data management

Data will be collected in hard copy (pencil and notebook) and transferred to a spreadsheet where it will be backed up daily. Upon conclusion of the cruise these data will contribute to the SCAR-MarBIN database in providing new distributional data on Antarctic invertebrates.

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2.4.8 Fish communities, distribution and production

R. Knust (AWI), K. Waetjen (AWI), M. Wetjen (AWI), T. Sandersfeld (AWI, not on board)

Objectives

The Antarctic fish fauna is dominated by a single suborder, the Notothenioidei (Perciformes).

Mainly five families within this suborder account more than 50 % of the species and more than 90 % of the fish biomass on the Antarctic shelf. The Notothenioidei, comprising more than 100 closely related species, include a wide range of ecotypes from sluggish demersal benthos feeders to herring-like pelagic shoaling species and large piscivorous predators. Despite the low diversity on higher taxonomic levels, the diversity of species within demersal communities on the high Antarctic shelf is extraordinarily high. On the eastern Weddell Sea shelf, the fish fauna is closely associated to the benthic sponge communities and adapted to the year-round cold water temperature of about -1,8°C. On the deeper slope (>600m) in warmer waters deep sea species like eelpouts (e.g. *Pachycara brachycephalum*) and snailfishes (Liparidae) occur and species diversity is much lower. From the southern Weddell Sea and Filchner area only a few data on fish distribution are available from expeditions in the early 1980s. Based on the results of these expeditions, the differences between the fish fauna of southern Weddell Sea in comparison to the eastern Weddell Sea seems to be minor in terms of species number and species composition (Schwarzbach 1988), but seems to be most evident in respect of fish biomass and production (Hubold 1992). Biomass of demersal fish species on the southern shelf is low and the estimated production is only one-fourths of the production on the eastern shelf. Pelagic fish biomass, in contrast, is distinctly higher on the southern shelf:

		DEMERSAL FISH FAUNA		**PELAGIC FISH FAUNA**	
		EASTERN SHELF	SOUTHERN SHELF	EASTERN SHELF	SOUTHERN SHELF
Biomass	**[$g*m^{-2}$]**	0.91	0.03	0.10	1.30
Production	**[$g\ m^{-2}\ y^{-1}$]**	0.43	0.10	0.02	0.25

Hubold 1992

Pelagic fish biomass and production in high Antarctic shelf areas is almost exclusively borne by a single species, the Antarctic silverfish (*Pleuragramma antarcticum*) (Hubold 1992, Hubold & Ekau 1987). This endemic, zooplankton-feeding species distinctly dominates the fish communities on the eastern Weddell Sea shelf and is one main food source for warm blooded animals like seals (Plötz et al. 2001).

The main objectives of this work pages are:

1. To investigate the spatial distribution, species composition, biomass and production of demersal and pelagic fish fauna in the Filchner area
2. To get samples for feeding and food web analysis (gut content, stable isotopes).

Work at sea

Species composition, biomass and size distribution of the demersal fish fauna will be determined from standard bottom trawl and Agassiz trawl catches on all study sites. The catches will follow the depth strata and will be located in water depths between 600 und 150m (bottom trawls), in water depth below 600m the Agassiz trawl will be used. Fishes will be determined, counted, measured and weighed. Otoliths will be removed for age determinations and the stomachs with their contents, respectively, will be preserved for later analyses. Muscle tissue will be sampled for stable isotopes analysis. All samples will be kept frozen at −30° C until further analysis. Additionally gut and stomach contents of various species will be sampled and analysed for identification of prey taxa. The catches will also provide samples and live animals for physiological and molecular experiments and analysis.

Data management

After data calculations, all results generated from this expedition will be published in the AWI data base PANGAEA (http://www.pangaea.de/)

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2.4.9 Temperature induced shifts in the fish distribution in the Weddell Sea

T. Sandersfeld (AWI, not on board), N. Koschnick (AWI), R. Knust (AWI)

Objective

Despite evidence for distribution shifts of single species and ecosystem changes as a reaction to global warming, little is known about interdependencies of temperature changes and energy budgets of single species. Most animals are highly adapted to the specific conditions met in their natural habitat. As a consequence of warming waters in the Southern Ocean, shifts in species distribution are expected with sub Antarctic species migrating southward to high Antarctic waters, while species from temperate regions might intrude sub Antarctic areas. Species distribution and abundance are driven by reproduction and growth. Growth and reproduction depend upon surplus energy being available after baseline costs of maintenance have been met. Differences in temperature dependent energy allocation are a crucial tool to understand species distribution limits and shifts in response to a changing environment.

Fish, as consumers and prey organisms alike, play an important role in Antarctic ecosystems. Fish species from high latitudes are assumed to have very low thermal sensitivity, which might indicate a lower capacity of this species to cope with rising water temperatures, thus possibly affecting ecosystem structures in a warming environment, especially in Antarctic regions. Moreover, potentially higher routine metabolic costs of species from higher latitudes might be an additional disadvantage in the challenge of climate change.

Work at sea

Fish caught by bottom or Agassiz trawls and baited traps will be collected and kept at habitat temperature in the aquarium container on board *Polarstern*. A group of these animals will take part in oxygen consumption measurements at habitat temperature, for determination of routine metabolism, as well as acute temperature increase, for determination of width of a thermal window. Whole animal oxygen consumption is often used as a proxy for maintenance costs, which is a basic parameter of an animal's energy budget. The collected data will complement an existing data set of routine metabolic rates of Antarctic fish species measured with the same experimental setup. Another group of live animals will be transported on board *Polarstern* to Germany for further energy budget studies in Bremerhaven.

Additionally, organ and tissue samples of different fish species will be collected for food web analysis as well as lipid carbon and protein content determination. Experimental results obtained on board as well as in Bremerhaven will be analysed regarding thermal sensitivity of Antarctic fish and contributes to a comparative energy budget study carried out in Bremerhaven and New Zealand.

2.4.10 Reproductive traits in Antarctic fish: a comparative analysis of Notothenioidei

E. Riginella (UniPadova), C. Mazzoldi (UniPadova, not on board),
M.B. Rasotto (UniPadova, not on board),
M. La Mesa (ISMAR-CNR, not on board)

Objectives

Teleost fish present large variability in reproductive traits. Individual investment in gonads varies at inter- and intra-specific levels, in relation to reproductive modalities and strategies. On the female side, investment in gonads and the trade off between egg size and egg number are more variable.

For what is known about their reproductive strategies, Antarctic and non-Antarctic Notothenioids show generally high reproductive investment, documented by high gonadosomatic indices, large egg sizes, prolonged gametogenesis and, in some cases, long male parental care. However, comparing species within the Notothenioids, a wide variability in the above mentioned reproductive traits has been observed. The comparative study of male and female reproductive apparatus, including morphology, gametogenesis and investment in gametes, is particularly interesting from an evolutionary biology point of view. Nototheniods are well known for their adaptations to the Antarctic environment, however within the Southern Ocean they inhabit different environments, characterized by differences in abiotic factors.

This study is aimed to comparatively analyse male and female reproductive traits of notothenioid fish, in relation to their ecological characteristics and environmental factors, taking into account the available information on phylogenetic relationships applying comparative methods such as independent contrasts. This study will also contribute to the conservation policies of this group, since the knowledge of reproductive characteristics of exploited species is recognized crucial for their management.

This study started with the collection of samples during the ANT-XXVII/3 (2011) and ANT-XXVIII/4 (2012) expedition cruises of *Polarstern*, in which gonad samples of 14 species (about 1500 specimens) of Nototheniidae and one Zoarcidae were collected, together with otoliths, along the Scotia Arc (Antarctic Peninsula, Elephant Island, South Orkney, South Georgia, South Shetland Islands) and Burdwood Bank. Furthermore the availability of samples taken from different sites will allow intra-specific comparison of life history traits along environmental gradients and highlight potential isolation of populations. Indeed, differences in the life history parameters of different populations of the same species, including reproduction, spawning and maturity, as well as age and growth, have been used as a basis for the identification of fish stocks. Estimates of these parameters are considered to be representative of individual fish within a putative stock, and can be used to distinguish among discrete stocks because they are phenotypic expression of the interaction between genotypic and environmental influences. Consequently, differences in life history parameters are assumed to be evidence that populations of fish are geographically and/or reproductively isolated, and therefore considered as discrete stock units for management purposes.

Work at sea

Samples will be collected according to species availability. Species, date and site of collection will be recorded, total length and weight, gonad weight will be measures, sex and macroscopic maturity will be assigned to each sample. Gonads or whole body cavity or trunks of males and females will be removed and fixed in Dietrich solution for histological analysis or 10 % seawater formaldehyde solutions for fecundity estimation and stored at room temperature. To estimate age at sexual maturity, otoliths will be removed and stored dry. For each species, and depending from availability, a minimum of 10 individuals per sex per stage should be preserved for the morphological description of gonads, a minimum of 20 mature females for fecundity and egg size estimation and 15 mature males of different size for analysis of within sex variability in gonad investment.

2.4.11 Molecular physiology and genetic profiling of Antarctic fish

C. Papetti (UniPadova), N. Koschnick (AWI), M. Babbucci (UniPadova),
M. Lucassen (AWI, not on board), L. Zane (UniPadova, not on board),
T. Patarnello (UniPadova, not on board)

Objectives

Thermal adaptation and phenotypic plasticity, which define the thermal niche and the kind of response to fluctuating environmental factors, are ultimately set by the genetic interior of an organism. Adaptations to the extreme cold appear to have evolved at the expense of high thermal sensitivity. Thus, the molecular physiology group at the AWI combines holistic expression profiling and the investigation of key functional traits for an in-depth understanding of climate sensitivity in Antarctic fish (Windisch et al. 2011, 2012). The molecular data are being interpreted in the context of physiologically and ecologically relevant parameters for meaningful conclusions. Example studies on fish mitochondria, resembling such a key functional trait, suggest that mitochondrial functioning and organisation underwent significant adaptations upon evolution to extreme cold (Mark et al., 2006, 2012; Windisch et al. 2011; Papetti et al. 2007; Chang et al. 2010). For Antarctic eelpout we identified a sensitively responding molecular network, which may explain higher performance including large rearrangements of the energy metabolism beyond the realized ecological niche (Windisch et al. 2011). Gene profiling by means of microarrays indicate a reciprocal relation between growth performance and the expression of the temperature-responsive genes of the transcriptome (Windisch et al. 2013). The principles and general applicability of these studies from Antarctic eelpout needs to be validated in other (highly cold-adapted) Antarctic fish phyla, which may differ in sensitivity to thermal challenges. The selectivity of identified genetic traits has to be judged against information about population structure and diversity provided by neutral genetic markers.

The Biology Department at the University of Padova has a long tradition in studying the population genetics of Antarctic fish. Ongoing projects on Antarctic fish include studies of the molecular phylogeny of Notothenioids and population genetics of *Chionodraco rastrospinosus*, *Chaneocephalus aceratus* and *Pleuragramma antarcticum* (Papetti et al., 2011, 2012; Marino et al, 2011). A long-term genetic monitoring of these species will allow verifying stability of differentiation pattern. Patterns of water circulation at small spatio-temporal scales may be modified by global warming leading to the possible reduction of suitable habitats and a strong impact of inter-annual variability in the recruitment and growth of both pelagic and benthic organisms.

The ongoing collaboration of both groups and the application of new approaches in conservation genomics including gene expression profiling on the background of physiological and ecological performance parameters, may give a major boost to the understanding of the evolution and population genetic structuring of Antarctic marine organisms, especially in response to global climate change. The ANT-XIX/9 cruise provides a unique opportunity to expand the sample collection of species from the cold edge of the Antarctic ecosystem, which will be essential for a comprehensive understanding of climate-driven evolution and sensitivity of highly cold-adapted species.

Work at sea

The new molecular analyses tools (in-depth sequencing, RNA-sequencing) present a quantum leap in analysing environmental samples from individual specimens. The continuous sampling of these samples will allow for holistic analyses of active genomes in a changing environment over time. During past cruises we have already collected a reasonable number of tissue samples from a broad set of fish species from other Antarctic areas.

Our work at sea is mainly integrated in the sampling programme of the other biological groups, and will provide the molecular basis for further studies on higher levels of biological organisation. By means of bottom trawls and baited bottom traps, we aim to catch Antarctic fishes, namely notothenioids, eelpouts but also other abundant species, along the cruise plot. Samples for molecular genetic and phylogenetic studies of various tissues will be taken from anaesthetized fish directly after catching and frozen instantaneously in liquid nitrogen or fixed in ethanol. DNA and RNA will be extracted from selected tissues for further analyses later at the AWI and the University of Padova.

Fish from bottom trawls will mainly be processed directly or after recovery for short time in the aquarium container (AWI024) by taking gills and other tissues after anaesthetizing and killing. Basic physiological parameters like ion composition, pHe, pHi, serum osmolality etc. will be determined for the respective specimens. Aliquots of gill tissue will be fixed for immunohistochemical and *in-situ* hybridisation analyses at the AWI (Hu et al. 2010; 2011). The data will be completed by determination of functional capacities, specific mRNA expression studies and protein quantification by means of antibodies (at the AWI). The mRNA samples will further be analysed for differentially expressed genes at the institute.

For ecophysiological experiments live specimens of fish (preferably caught by means of baited traps) will be kept on board “*Polarstern*” at environmental temperature conditions and will be sent alive to the AWI on the following leg (in collaboration with R. Knust, T. Sandersfeld, AWI).

Samples of further species (namely cephalopods and Antarctic krill) will be collected for genetic analyses (population genetics and expression profiling) in comparison to other Antarctic regions (in particular western Antarctic Peninsula).

We aim to extend and complete our sample set of Antarctic fishes especially by high-Antarctic species from the Filchner area to provide a comprehensive picture of the genetic basis of climate-driven evolution and sensitivity of highly adapted species.

Data management

All data collected during this cruise will be available for the other participants and will be provided upon request. All samples will be stored at the AWI and Biology Department of Padova University, respectively, and may become available to scientists from other institutions on request. All data resulting from the analysis of the population samples collected during this cruise will be available through publications or reports.

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2.5 SEAL RESEARCH AT THE FILCHNER OUTFLOW SYSTEM (SEAFOS)

H. Bornemann (AWI), W.C. Oosthuizen (MRI), M.N. Bester (MRI)

Objectives

Seal research at the Filchner Outflow System (SEAFOS) is one of the key elements within the investigations of the Filchner Outflow System on board *Polarstern*, and closely related to its parallel projects BATFOS, SODFOS and HOTFOS. By including biotic components from phytoplankton via fishes to seals and abiotic parameters such as bottom topography, sediment structure, and hydrographic features, these projects comprehensively aim to investigate the Filchner Trough Outflow System. Here the outflow of ice shelf water of the Filchner Ronne Ice Shelf interacts with warm deep water of the Weddell Gyre circulation. This interaction is supposed to be the primary cause that converts this area in a biological "hotspot" where upper and intermediate trophic level interactions are maximised. Physical, biogeochemical and ecological studies in the target area shall characterize this hotspot in detail.

Our earlier studies on migration behaviour of male southern elephant seals, satellite tagged in April and May 2000 on King George Island, showed that some individuals travelled into the dense winter pack ice of the southern Weddell Sea until they reached the region of the Filchner Trough outflow, covering a distance of more than 2,000 nautical miles (Tosh et al. 2009). The tagged seals remained in a localized shelf-slope area at the outflow if the Filchner Trough (~74.5°S; 30-40°W) for several months. Area restricted movements within this locality during the study period indicate active foraging in a locally attractive feeding spot. The factors contributing to this hotspot of enhanced food availability are largely unexplored. The tendency of southern elephant seals to forage on the Antarctic continental shelf within the pack ice has been illustrated also for seals from Bouvetøya (Biuw et al. 2010), Iles Kerguelen (Bailleul et al. 2007) and Macquarie Island (Bradshaw et al. 2003). Weddell seal foraging behaviour has been linked to the presence of the Antarctic silverfish *Pleuragramma antarcticum* in the Weddell Sea (Plötz et al. 2001). The presence of this dominant pelagic fish species (Hubold 1985), likely influences the movement patterns of female elephant seals from King George Island (Bornemann et al. 2000) and forms an important part of the pelagic fish diet of southern elephant seals from King George Island (Daneri & Carlini 2002). Our data on southern elephant seals and those derived from other recent tagging studies of Weddell seals (Nicholls et al. 2008; Årthun et al. 2012) represent the only and still preliminary behavioural investigations in foraging behaviour and habitat use of seals in the south-western Weddell Sea. It is assumed that other marine endotherms such as emperor penguins of the breeding colony at Gould Bay (77°30'S, 48°30'W) with an estimated population of 7,500 breeding pairs (Woehler 1993; Fretwel et al. 2012) could also forage towards the same region. However, reports on top predator abundances in this region are extremely scarce. Latest aerial seal surveys by the AWI Polar 2 aircraft along the eastern coast of the Weddell Sea (Plötz et al. 2011a-e) did not go far beyond the Drescher Inlet at

19°W (Southwell et al. 2012), and helicopter surveys from aboard *Polarstern* in the Weddell Sea in 2004/2005 (ANT-XXII/2) concentrated north of 69°S (Flores et al. 2008). Just one opportunistic flight transect was flown in 1998 with a fixed wing aircraft by a British team in the area of the Berkner and Belgrano Banks west of the Filchner Trough (Forcada & Trathan 2008; Forcada et al. 2012; Southwell et al. 2012). However, this transect did not reveal regional abundances of pack ice seals in the area of the Filchner Trough, since the analyses applied to the whole sector between 90°W and 30°W and 60°S to 80°S (Forcada & Trathan 2008; Forcada et al. 2012; Southwell et al. 2012). Although two helicopter flights from aboard *Polarstern* in 1998 (ANT-XV/3) extended to 45°W, and thus within the focal area (Bester & Odendaal 1999; Bester & Odendaal 2000), the results did not inform on local abundances of seals. The large extent of the complete survey, covering 7°W to 45°W with only 15 transects, concentrated on the east coast of the Weddell Sea between 7°W and 26°W (12 transects), rather than on the area around the Filchner Trough where only the aforementioned two transects were flown (Bester & Odendaal 1999; Bester & Odendaal 2000). Early cruise reports of *Polarstern* and other research vessels contain few data on seal sampling in this area and the scientists involved communicated opportunistic sightings of southern elephant seals (Kohnen 1982). They also had the impression of enhanced occurrences of seals and other marine endotherms during voyages towards the former Filchner Station at the Filchner-Ronne Ice Shelf. As a result, we hypothesized that the area constitutes a biological hotspot.

2.5.1 Abundance and distribution of seals

M.N. Bester (MRI), W.C. Oosthuizen (MRI), H. Bornemann (AWI)

Objectives

This approach concentrates on an aerial seal census survey over ice covered sea in order to get data on potential density gradients and density estimates for seals towards and within the area of the Filchner Trough. Historically, methods for seal census surveys comprise a high degree of heterogeneity, which restricts the comparability of data taken with different methodological approaches. In order to ensure that novel findings can be compared with those from earlier surveys, and thus contribute to querying the working hypothesis, we aim to survey using the exact same methods applied in the only recent data set that is available for the Weddell Sea. This data set was generated by Bester and Odendaal (1999, 2000) from aboard *Polarstern* in 1998 during the multinational circum-Antarctic wide Antarctic Pack Ice Seal (APIS) Programme of SCAR. The analyses of APIS were recently completed (Southwell et al. 2012), and are comparable in their methods with seal surveys that were carried out more easterly in the Weddell Sea by Bester et al. (1995; *cf.* Erickson et al. 1993). A survey with the AWI research aircraft Polar 6 in November 2013 will precede the helicopter survey from aboard *Polarstern*.

Work at sea

The line transect survey design will be adjusted according to ice conditions. Under ideal weather conditions, up to 20 transects of up to 120 min duration each will be flown at a height of 200 feet (~60 m) and at a velocity of 60 knots (~110 km/h) over sea ice. Transects should not exceed 35 km distance from each other, and shall be flown perpendicular to the 1,000 m bathymetric contour. Seals will be counted by two observers through sighting bars attached to the windows on each side of the back seats of the helicopter. Flight times and GPS locations will be noted at 10 min intervals, and sightings (counts) in units of three min. Counts will be made in conjunction with the date, time, location of each observation, sea ice concentration and eventually size of ice floes, and photographs of sea ice will be taken by a third observer in the co-pilot's seat. Seal counts will be done through two sighting bars made from polycarbonate, fastened by suction caps at each of the side windows of the helicopter (*cf*. Bester & Odendaal 1999, 2000). Physical check marks on the sighing bars delineate six virtual census strips denoted as bins (when being projected on the ice) and represent vertical angle intervals at 10°, the innermost angle (30° from vertical) being treated as the centreline of the transect by each observer, and the outermost bin stretching to the horizon. Thus five intervals are created corresponding to strip widths of 53, 71, 108, 204 and 587 feet on the ice on each side of the helicopter, the outermost (6th) bin stretching to the horizon. These are connected by an obscure strip (bin) underneath the helicopter of 230 feet. The bins are used to estimate the perpendicular distances at which seals, or groups of seals, are seen from each side of the helicopter. In order to calibrate the sighting bars to each observer, the helicopter will fly over flagged marker poles that will be laid out on the shelf ice in proximity to the Neumayer Station III.

The seal census protocol explained above enables the survey personnel to identify seals sighted to species level and to calculate adjusted density estimates for the seals found in the survey area. It is mandatory that the flights correspond with the seals haulout maxima on the ice peaking between 12:00 -13:00 local apparent time (LAT). Thus, transects need to be scheduled for between 11:00 (starting) and 16:00 (ending) approximate (LAT). Since the Filchner Trough is located ca. -3h relative to UTC, the flights should be scheduled between 14:00 and 19:00 UTC, under consideration of the Filchner Trough area circumscribed (coverage) by Median Latitude: -74.50 * Median Longitude: -34.00 * South-bound Latitude: -75.50 * West-bound Longitude: -43.00 * North-bound Latitude: -73. 00 * East-bound Longitude: -26.00. In case of unfortunate ice conditions that may hamper *Polarstern* to reach the investigation area at the Filchner Trough, an alternative survey will be carried out along the east coast of the Weddell Sea.

Expected results

We expect sightings of crabeater seals (*Lobodon carcinophaga*), Weddell seals (*Leptonychotes weddellii*), leopard seals (*Hydrurga leptonyx*), Ross seals (*Ommotophoca rossii*), and - if at all - only occasionally southern elephant seals (*Mirounga leonina*). By mapping occurrences of seals on sea ice, this survey will contribute to the interpretation of top predator aggregations within the area of the Filchner Trough. Together with information on potential seal density gradients, the results shall elucidate the proposed biological hotspot area in synchrony with *Polarstern* cruise ANT-XXIX/9 as outlined above.

Data management

All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de), and will be attributed to a consistent project label denoted as "Marine Mammal Tracking" (MMT, see http://www.pangaea.de/search?q=project:label:mmt).

2.5.2 Foraging behaviour of seals and oceanography

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Objectives

This approach concentrates on deployment of satellite transmitters on seals on the sea ice in order to get data on the seals' foraging behaviour and concurrent hydrographic data towards and within the area of the Filchner Trough. Only three recent publications provide evidence for extended residence times of satellite tracked southern elephant seals (Tosh et al. 2009) and Weddell seals (Nicholls et al. 2008; Årthun et al. 2012) in the area of the Filchner Trough. Long-distance tracking of marine mammals in the Southern Ocean by satellite relies on the ARGOS system. ARGOS satellite transmitters for marine mammal applications are designed to provide the animals' at-sea locations and transmit data to the satellites when the seals surface. CTD-combined ARGOS satellite-relayed dive loggers (CTD-SRDLs) have the capabilities to record also *in-situ* water temperature and conductivity for the entire migrations of tracked seals. Such data are of suitable quality to characterise the oceanographic settings utilised by seals (e.g. Nicholls et al. 2008; Boehme et al. 2009; Meredith et al. 2011), and are complementary to the oceanographic investigations as described in SODFOS. During the annual moult the units will be shed, and thus tracks and concurrent behavioural and hydrographic data can be collected over a period of a year at maximum. The immediate *in-situ* data on the seals' foraging depths in the area will be used to align the trawl depths of the fishing gear on board Polarstern (HOTFOS). The reconciliation of data on the seals' diving behaviour (SEAFOS) and on the hydrographic features (SODFOS) with information on the occurrence and biomass of the seals' prey (HOTFOS) aims to describe the upper trophic level interactions at the Filchner Trough. Adult Weddell seal males (*Leptonychotes weddellii*) will be preferably instrumented with CTD-SRDLs, since they can be expected to remain over the investigation area throughout the year due to their "maritorial" behaviour. Weddell seals, furthermore, dive to depths of up to 600 m (Kooyman et al. 1966), and their foraging dives can yield information on both potential pelagic and demersal or benthic prey in the investigation area. The deployments of CTD-SRDLs will preferably take place after the seals have completed their annual moult. The devices will be glued to the new fur of anaesthetized seals using quick setting epoxy resin. For the purpose of instrumentation, the seals need to be anaesthetized following the methods as described in Bornemann et al. (1998); Bornemann & Plötz (1993) and Bornemann et al. (2013). Drugs are initially administered intramuscularly by remote injection using blow-pipe darts. Follow-up doses are usually given intramuscularly by direct manual injection or in rare cases intravenously. The dose regime involves the drugs as listed below and dosages or respectively dose ranges vary depending on initial or follow-up injections. The seals will be immobilized with ketamine/xylazine or with tiletamine/zolazepam combinations. Depending on the course of the immobilisation, dosages need to be individually adjusted and will be complemented by the same drug to maintain or extend the immobilisation period on demand. Benzodiazepines (diazepam or climazolam) may be needed to attenuate muscle tremors. Atipamezol will be used to reverse the xylazine component in the xylazine/ketamine immobilisation, and flumazenil may be used as antidote for the unlikely situation of an overdose of benzodiazepines. Doxapram is exclusively reserved for the unlikely necessity to stimulate breathing in the case of extended periods of apnoea, when mechanical obstructions of the upper airways can be excluded. The length and girth of each seal will be measured. The mass of the seal and the dosages will be determined in a post hoc calculation via photogrammetry (de Bruyn et al. 2009). In case of heavy ice conditions that may hamper *Polarstern* to reach the area of the Filchner Trough, an alternative survey will be carried out along the east coast of the Weddell Sea. This would also include instrumentation of Ross seals (*Ommatophoca rossii*). Deployments of CTD-SRDLs on southern elephant seals (*Mirounga leonina*) at King George Island in October 2013 will precede the *in-situ* deployments of transmitters from aboard *Polarstern* in the area of the Filchner Trough.

Work at sea

Up to 10 satellite-relayed dive loggers combined with CTD's (called CTD-SRDLs) will be deployed preferably on Weddell seals to study their foraging behaviour, and their profiling dives will allow sampling of concurrent data on Conductivity, Temperature at Depths in order to complement the oceanographic investigations (SODFOS) and to provide data on the seals' foraging depths to align the trawl depths (HOTFOS). On top of the instrumentation, a blood sample of 30 ml will be taken together with hair and whisker samples. Blood samples will be centrifuged on board, separated in red blood cells and serum and both deep frozen at -80°C. Within the serum fraction we aim to analyse for prey specific biomarker proteins that allow for reconciliation with the seals' prey spectrum (e.g. octopine in octopods, specific amines in fishes, homarines in molluscs and crustaceans) in later laboratory analyses (*cf*. Hochachka et al. 1977; Ito et al. 1994; Eisert et al. 2005; Eder et al. 2010). These data can hint at the recent prey spectrum within a couple of days prior to blood sampling using both serum and blood cell fractions. The hair and whisker samples will be used to get retrospective information on the prey spectra on intermediate time scales up to a couple of months by means of component-specific isotope analyses (*cf*. Lewis et al. 2006; Newsome et al. 2010; Hückstädt et al. 2012a, 2012b). *In-situ* collection of naturally regurgitated vomitus, faecal samples, etc. complements the sampling protocol.

From each of the CTD-SRDL tagged seals we expect per day about 4 temperature, salinity and depth profiles almost in real time which will allow us to study how changes in the underwater environment alter prey distribution beneath the ice as indicated by the seals' individual diving and foraging behaviour. We furthermore expect that these key physical oceanographic variables collected from hitherto under-sampled coastal shelf regions may assist the refinement of computer models of the Southern Ocean circulation. Sampling of blood and other material will provide information on the seals' prey spectrum in later laboratory analyses.

Data management

All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de), and will be attributed to a consistent project label denoted as "Marine Mammal Tracking"

(MMT, see http://www.pangaea.de/search?q=project:label:mmt).

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45	Steinmetz	Richard	AWI	Technician, biology
46	Vaupel	Lars	Heliservice	Pilot, helicopter service
47	Vortkamp	Martina	AWI	Technician, biology
48	Wachsmuth	Leander	AWI	Student, geodesy
49	Wätjen	Kai	AWI	Scientist, biology
50	Wetjen	Maj	AWI	Scientist, biology
51	Wisotzski	Andreas	AWI	Scientist, oceanography
52	Zapata	Rebecca	ICM-CSIC	Scientist, biology

2.8 SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Schwarze, Stefan	Master
Grundmann, Uwe	1.Offc.
Farysch, Bernd	Ch. Eng.
Fallei, Holger	2. Offc.
Langhinrichs, Moritz	2.Offc.
Peine, Lutz	3.Offc.
Pohl, Claus	Doctor
Koch, Georg	R.Offc.
Grafe, Jens	2.Eng.
Minzlaff, Hans-Ulrich	2.Eng.
Holst, Wolfgang	3. Eng.
Scholz, Manfred	Elec.Tech.
Fröb, Martin	Electron.
Hüttebräucker, Olaf	Electron.
Nasis, Ilias	Electron.
Himmel,Frank	Electron
Loidl, Reiner	Boatsw.
Reise, Lutz	Carpenter
Scheel, Sebastian	A.B.
Brickmann, Peter	A.B.
Winkler, Michael	A.B.
Hagemann, Manfred	A.B.
Schmidt, Uwe	A.B.
NN	A.B.
Wende, Uwe	A.B.
Bäcker, Andreas	A.B.
Guse, Hartmut	A.B.
Preußner, Jörg	Storek.
Teichert, Uwe	Mot-man
Schütt, Norbert	Mot-man
Elsner, Klaus	Mot-man
Voy, Bernd	Mot-man
Pinske, Lutz	Mot-man
Müller-Homburg, Ralf-Dieter	Cook
Silinski, Frank	Cooksmate
Martens, Michael	Cooksmate
Czyborra, Bärbel	1.Stwdess

Name	**Rank**
Wöckener, Martina	Stwdss/KS
Gaude, Hans-Jürgen	2.Steward
Silinski, Carmen	2.Stwdess
Arendt, Rene	2.Steward
Möller, Wolfgang	2.Steward
Sun, Yong Shen	2.Steward
Yu, Kwok Yuen	Laundrym.

ANT-XXIX/10

08 March 2014 – 13 April 2014

Cape Town – Bremerhaven

Chief Scientist
Hartwig Deneke

Coordinator
Rainer Knust

3. EXPEDITION ANT-XXIX/10

3.1 ÜBERBLICK UND FAHRTVERLAUF

Hartwig Deneke (TROPOS)

Die Überführungsreise ANT-XXIX/10 von Kapstadt nach Bremerhaven beendet eine außer–gewöhnlich lange Forschungskampagne auf der Südhalbkugel inklusive Überwinterung, und führt das Forschungsschiff *Polarstern* nach 1,5 Jahren zurück in ihren Heimathafen Bremerhaven.

Im Rahmen des OCEANET-Programms werden auf dieser Transferfahrt erneut detaillierte Beobachtungen der Atmosphäre, insbesondere von Aerosole und Wolken, und zu ihrem Einfluss auf die atmosphärische Strahlung sowie den Austausch zwischen Atmosphäre und Ozean durchgeführt. Zusätzlich zu den bisherigen Messungen ist erstmalig ein Wolkenradar der amerikanischen National Oceanographic and Atmospheric Agency (NOAA) zur Vertikalprofilierung von Wolken an Bord. Ebenso sind zum ersten Mal Messungen von Spurengaskonzentration mittels Spektrometern Teil des Messprogramms von OCEANET. Eine weitere Besonderheit der Fahrt ist die geplante kurzfristige Anpassung der Route an die Überflüge des sogenannten A-Train, einer Satellitenkonstellation, die inbesondere ein weltraumgestütztes Aerosol-Lidar (CALIOP) und Wolkenradar (CLOUDSAT) beinhaltet. Hierdurch ergibt sich die einzigartige Gelegenheit, vertikal aufgelöste Wolken- und Aerosolprofile aus Satelliten- und Bodenperspektive über dem Ozean zu vergleichen.

Die Verbreitung und Häufigkeit von Vögeln und marinen Säugern sollen durch Sichtungsdaten von der Brücke aus entlang der Route erhoben werden. Des weiteren werden Aquarien mit Fischen aus den polaren Regionen nach Bremerhaven überführt, und nach einem Zwischenstopp in Las Palmas sollen instrumentelle Erprobungen im Golf von Biscaya durchgeführt werden.

SUMMARY AND ITINERARY

The transfer cruise ANT-XXIX/10 from Cape Town to Bremerhaven ends an extraordinarily long research campaign on the Southern Hemisphere, including overwintering in Antarctica. After 1.5 years, *Polarstern* will finally return to its home port.

In the framework of the OCEANET programme, detailed observations of the atmosphere will be carried out, targeting aerosols and clouds and their effect on atmospheric radiation and atmosphere-ocean exchange. In addition to pervious measurements, a W-band cloud radar from the US National Oceanographic and Atmospheric Agency (NOAA) will be operated on board for the first time providing vertical cloud profiles. Also, spectroscopic measurements of trace gas concentrations will be carried out as part of OCEANET. As a further exceptional aspect, the route will be chosen to obtain optimal matchups with satellites from the A-Train constellation, specifically the CALIOP aerosol lidar and the CLOUDSAT cloud radar. The resulting datasets will offer the unique opportunity to compare vertically resolved profiles of clouds and aerosols from the satellite and ground-based perspective.

The distribution and frequency of sea birds and marine mammals along the route will be determined by observers. Also, aquaria with Antarctic fish will be transported to Bremerhaven for further studies, and some instrumental validation will be carried out after a stop in Las Palmas en route to Bremerhaven.

3.2 AUTONOMOUS MEASUREMENT PLATFORMS FOR ENERGY AND MATERIAL EXCHANGE BETWEEN OCEAN AND ATMOSPHERE (OCEANET): ATMOSPHERE (S-577)

S. Bley (TROPOS), B. Blomquist(NOAA), A. Foth (LIM), S. Fuchs (TROPOS), K. Moran(NOAA), M. Merkel (TROPOS), J. Walther (TROPOS), NN., NN., NN., NN., NN., NN.

Not on board: A. Macke (TROPOS), D. Althausen (TROPOS), A. Wiedensohler (TROPOS), A. Butz (KIT), C. Fairall (NOAA)

Objectives

a) Radiation & microwave remote sensing

The net radiation budget at the surface is the driving force for most physical processes in the climate system. It is mainly determined by the complex spatial distribution of humidity, temperature and condensates in the atmosphere. The project aims at observing both the radiation budget and the state of the cloudy atmosphere as accurate as possible to provide realistic atmosphere-radiation relationships for use in climate models and in remote sensing. While similar experiments have been performed from land stations, only few data from measurements over ocean areas exist. The present project is part of the "Meridional Ocean Radiation Experiment" MORE which uses Atlantic transfers of various research vessels for the combined measurements of the atmospheric state since 2004. The main project behind this cruise is the WGL-PAKT Initiative OCEANET.

A multichannel microwave radiometer will be applied to continuously retrieve temperature and humidity profiles as well as cloud liquid water path over the ocean. Time series of these profiles will show small scale atmospheric structures as well as the effects of the mean state of the atmosphere and its variability on the co-located measurements of the downwelling shortwave and longwave radiation. The atmospheric profiles will also be used to validate the satellite based profiles from the IASI instrument onboard the new European polar orbiting satellite MetOp. Atmospheric aerosol optical thickness will be measured by means of hand held sun photometer and spectral solar radiometer. Most instruments will be integrated in the new container-based atmosphere observatory.

b) Lidar measurements

Since more than 15 years TROPOS has developed and operated advanced lidar systems in order to study optical and microphysical aerosol properties in the troposphere. The system PollyXT, a semi-autonomous multiwavelength polarization Raman lidar will be operated inside a container, together with the radiation and microwave sensing equipment. The lidar is able to measure independently profiles of particle backscatter at three wavelengths and extinction at two wavelengths, which allows identifying particle type, size, and concentration. Additionally particle depolarisation is measured in order to discriminate between spherical and non-spherical particles, e.g. biomass-burning smoke vs. mineral dust or water clouds vs.

ice clouds. Recently the lidar was equipped with a measurement channel for atmospheric water-vapour, too. The data are used to characterize long-range transport of aerosol and identify pollution. The determined height-resolved aerosol extinction completes the radiation measurements. In this way, the radiative influence of single lofted aerosol or cloud layers can be calculated with radiation-transport models.

c) W-Band cloud radar observations

A vertically pointing, pitch-roll stabilized W-band Doppler radar designed for ship-born operations from NOAA's Physical Science Division will be operated on board of *Polarstern*. This instrument offers the unique opportunity for detailed investigations of the dynamics and microphysics of the marine clouds encountered along the latitudinal cross section from Cape Town to Bremerhaven. Profiles of radar reflectivity and Doppler spectra will be recorded, which provide information on the vertical extent, structure and particle velocity of clouds, and will allow to study in-cloud microphysical and turbulent processes. Together with the lidar and microwave radiometer, the radar will offer an unprecedented characterisation of the atmospheric profiles including aerosols and clouds above *Polarstern*, and enable studies of their influence on the surface radiation budget.

d) Aerosol *in-situ* measurements

The portfolio of the Aerosol Group at TROPOS includes the *in-situ* characterisation of atmospheric aerosols in urban as well as remote background atmospheres, the characterisation of regional and urban air quality, the examination of hygroscopic particle properties, the measurement and simulation of *in-situ* aerosol optical properties, the investigation of atmospheric transport processes, and the development of new and improved instruments for physical aerosol characterisation. Onboard *Polarstern* all measurements will be conducted inside a temperature-controlled container laboratory, and focus on the particle characterisation using high-end scientific instruments in order to study:

- physical aerosol properties using an Aerodynamic Sizer (APS) and Tandem Differential Mobility Analyser (TDMPS) for particle number size distributions from 3 nm to 10 µm, and a Humidifying Differential Mobility Particle Sizer (HDMPS) for the hygroscopic growth of the particles;
- optical properties using a nephelometer and an absorption photometer to measure the particle light scattering and absorption coefficients, respectively; and
- particle chemical composition using a High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToFAMS) for the non-refractory PM1.

e) Sea surface chemistry

The main objective of the chemical analysis is to characterise the chemical composition of the ocean surface film in parallel to the chemical and physical characterisation of the marine aerosol in order to identify the particle-based exchange of organic compound and hence carbon.

f) Remote sensing of atmospheric greenhouse gas concentrations (RemOteC)

The man-made release of carbon dioxide (CO_2) and methane (CH_4) to the atmosphere drives an enhanced greenhouse effect that is considered responsible for climate change. Our research group at KIT develops and operates robust and versatile spectrometers that allow for measuring total column CO_2 and CH_4 concentrations in the Earth's atmosphere. We generally aim at determining the target concentrations with accuracy better than 0.3 % in order to validate coinciding satellite measurements and to extract information on sources and sinks that control the atmospheric concentrations.

While total column greenhouse gas concentrations are monitored on a regular and long-term basis by several land-based stations around the world, only a few measurements are conducted close to the oceans or on research vessels and ships. Deployment of our instruments on *Polarstern* aims at demonstrating that the instrumentation is sufficiently robust for ship deployments while achieving the accuracy required for satellite validation and source/sink estimation.

The observational technique relies on absorption spectroscopy in the shortwave infrared spectral range where telluric absorption of the target species can be observed in direct sunlight. Building on solar absorption spectroscopy, our approach requires a sun-tracking device that compensates movements of the measurement platform. We plan for simultaneously operating a grating and a Fourier Transform spectrometer in order to guarantee data quality by comparing the two data records.

g) Air-sea interaction and radiosoundings

Great emphasis has to be put on air-sea fluxes of momentum, sensible and latent heat to improve numerical models of weather forecast and climate simulations since oceans cover 71 % of the earth's surface. The fluxes of sensible and latent heat are also of importance for the energy budget of the ocean and the atmosphere. To estimate the turbulent fluxes of momentum, sensible heat, latent heat, CO_2, a sonic-anemometer and an open path hygrometer will be mounted. Measurements are taken at a sampling rate of 10 Hz respectively 30 Hz (sonic-anemometer) allowing to derive the fluxes by applying the inertial dissipation method. This method relies on measurements at high frequencies, less distorted by the motion and the superstructure of the ship than the covariance technique. Radiosoundings, performed additionally to the daily ones of the DWD, will serve as input for an investigation of the QBO (quasi-biennial oscillation). Further the data will be used, as the turbulence flux measurements, for validation studies of model and reanalysis data. Precipitation measurements will take place using an optical disdrometer, giving precipitation rates as well as drop size spectra. These data will be used also for validation studies of model and reanalysis data.

Work at sea

Upon departure both container based atmosphere observatories will be installed at the observation deck of *Polarstern*. Most measurements will be performed underway and continuously. The following individual instruments are combined:

1) Multichannel microwave radiometer HATRPO. The instrument requires occasional calibrations with liquid nitrogen as well as tipp-calibrations under calm sea and homogeneous atmospheric conditions.
2) Whole sky imager for cloud structure measurements
3) Multiwavelength polarization Raman lidar PollyXT
4) Vertical profiles of radar reflectivity from the NOAA W-band cloud radar
5) Handheld sun photometer (Microtops) for aerosol and cloud optical thickness
6) *In-situ* aerosol measurements
7) -Sonic anemometer USA-1 to measure the wind components and temperature absorption hygrometer to measure water vapor
8) -Radiosoundings
9) -Optical disdrometer to estimate precipitation rates and drop size spectra

Expected results

1) 2d structure of the clear sky atmosphere and corresponding net radiation budget.
2) Horizontal and vertical structure of clouds from microwave and cloud radar, and its effect on the downwelling shortwave and longwave radiation

3) Vertical structure of temperature and humidity as well as its variability for validation of satellite products
4) Vertical profiles of tropospheric aerosols and their effect on radiation
5) Near-surface aerosol size distributions and their physical and chemical compositions
6) Chemical composition of surface films and relation to evaporated organic materials and their aggregation in aerosols.
7) Latitudinal cross section of total column CO_2 and CH_4 concentrations, including satellite validation and synergistic use together with atmosphere-ocean flux measurements in order to constrain carbon cycle models.
8) Turbulent fluxes of momentum, sensible, and latent heat
9) Wind information from the upper troposphere and lower stratosphere for the investigation of the QBO
10) Precipitation rates for model validation

Data management

Measurement data will be made available through the PANGAEA database after the cruise.

3.3 GENETIC PROFILING AND ECOPHYSIOLOGY OF ANTARCTIC FISH (S-614)

G. Krieten (AWI), NN., N.N, N.N.

Not onboard: M. Lucassen (AWI), C. Papetti (Uni Padova), R. Knust (AWI)

Objectives

Thermal adaptation and phenotypic plasticity, which define the thermal niche and the kind of response to fluctuating environmental factors, are ultimately set by the genetic interior of an organism. Adaptations to the extreme cold appear to have evolved at the expense of high thermal sensitivity. Thus, the molecular physiology group at the AWI combines holistic expression profiling and the investigation of key functional traits for an in-depth understanding of climate sensitivity in Antarctic fish (Windisch et al. 2011, 2012). The molecular data are being interpreted in the context of physiologically and ecologically relevant parameters in collaboration with fish ecologists for meaningful conclusions.

Example studies on fish mitochondria, resembling such a key functional trait, suggest that mitochondrial functioning and organisation underwent significant adaptations upon evolution to extreme cold (Mark et al., 2006, 2012; Windisch et al. 2011; Papetti et al. 2007; Chang et al. 2010). For Antarctic eelpout we identified a sensitively responding molecular network, which may explain higher performance including large rearrangements of the energy metabolism beyond the realized ecological niche (Windisch et al. 2011). Gene profiling by means of microarrays indicate a reciprocal relation between growth performance and the expression of the temperature-responsive genes of the transcriptome (Windisch et al. 2013). The principles and general applicability of these studies from Antarctic eelpout needs to be validated in other (highly cold-adapted) Antarctic fish phyla, which may differ in sensitivity to thermal challenges. The selectivity of identified genetic traits have to be judged against field information about the ecology and population structure/diversity provided by neutral genetic markers.

The application of new approaches in conservation genomics including gene expression profiling on the background of physiological and ecological performance parameters, may give a major boost to the understanding of the evolution and population genetic structuring of Antarctic marine organism, especially in response to global climate change.

These approaches require live fish for laboratory-controlled growth and performance measurements at the home institute together with advanced molecular genetic analysis techniques. Therefore, fish collected during the former cruise leg will be transported alive at natural water conditions to the home institute.

Work at sea

Fish from bottom trawls and baited fish traps, caught during ANT-XIX/9 will be kept alive in our aquarium container (AWI024) and further recirculating aquaria systems under environmental temperature conditions to be analysed at the home institute.

Basic physiological and biochemical analytics will be extended from the former leg on frozen samples, including DNA and RNA extraction, enzymatic measurements and characterisation of blood parameters.

Expected results

We aim to extend and complete our sample set of Antarctic fishes especially by high-Antarctic species from the Filchner area to provide a comprehensive picture of the genetic basis of climate-driven evolution and sensitivity of highly adapted species.

Data management

All samples obtained from the fishes after experimentation will be stored at the AWI and Biology Department of Padova University, respectively, and may become available to scientists from other institutions on request. All data resulting from the analysis of the population samples collected during this cruise will be available through publications or reports.

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Windisch, H Frickenhaus, S John, U Knust, R, Pörtner, H-O, Lucassen, M (2013) Stress response or beneficial temperature acclimation: Transcriptomic signatures in Antarctic fish (*Pachycara brachycephalum*). Submitted.

Windisch, H, Kathöver, R, Pörtner, HO, Frickenhaus, S, Lucassen, M (2011) Thermal acclimation in Antarctic fish: Transcriptomic profiling of metabolic pathways. *Am J Physiol* Regul Integr Comp Physiol 301(5): R1453-66.

Zhuang, X, C H C Cheng (2010) "ND6 Gene "lost" and found: Evolution of mitochondrial gene rearrangement in Antarctic Notothenioids". *Molecular Biology and Evolution* 27(6): 1391-1403.

3.4 UPPER TROPHIC LEVELS: AT-SEA DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS (S-597)

C. R. Joiris, PolE (not on board), R.-M. Lafontaine, Q. Goffette, NN (PolE)

Objectives

As a complement to our long-term study of the at-sea distribution of marine mammals and seabirds in polar ecosystems, this large-scale study will include the effects of water masses and fronts and slopes of the continental shelf. Very little is known about seabirds, and much less even about cetaceans, especially in the tropical waters: this study is aimed at providing base-line information allowing to detect later possible changes in density and/or geographical distribution, possibly as consequences of climate changes.

Work at sea

Distribution of marine mammals and seabirds will be determined during transect counts from the bridge, at 18 m above sea level. They are lasting half an hour each without width limitation on a continuous basis, light and visibility allowing (see description and discussion in Joiris 2007; Joiris and Falck 2010). The animals are detected with the naked eye, and observations confirmed and complemented with binoculars (10x42) when useful; photographic documents are also used, especially for species difficult to identify. Results will be presented as basic unmodified data, *i.e.* numbers encountered per half-an-hour transect count. Density can also be calculated on the basis of specific detection limits established by this team in function of size, colour and behaviour (jizz)(Joiris 2007; Joiris and Falck 2010) and mean ship's speed.

Expected results

We expect to improve our knowledge about the mechanisms and hydrological factors influencing the seabird and marine mammal distribution: water masses and fronts, continental shelf, reflecting ecological differences in prey availability. Data will be compared with the ones already recorded along two such transects (October – December 2011 and April – May 2012).

Data management

Results, together with the basic DShip data (mainly water temperature, salinity and depth) will be included in our PolE dataset in a first phase (contact: crjoiris@gmail.com), and after publication in an international journal in the AWI dataset.

Selected references

Joiris CR and Falck E. 2010. Summer at-sea distribution of little auks *Alle alle* and harp seals *Pagophilus (Phoca) groenlandica* in the Greenland Sea: impact of small-scale hydrological events. *Polar Biol.* (2011) **34:** 541-548. DOI: 10.1007/s00300-010-0910-0. Online: 03 November 2010.

3.5 SEA TRIALS AND SYSTEM APPROVAL OF THE MULTIBEAM SONAR „HYDROSWEEP DS III“DURING ANT-XXIX/10

B. Dorschel, L. Jensen, R. Krocker (AWI); J. Rogenhagen (RFL); S. El Naggar (not on board) (SELNA); J. Ewert (ATLAS Hydrographic); P. Wintersteller (MARUM)

Objectives

The multibeam sonar system ATLAS Hydrosweep DS on board *Polarstern* was updated from version DS II to DS III in October 2010. Some of the new features of DS III were not working as expected. Chirp mode, multiping mode and the bottom detector were newly developed and installed in October 2013. Sea trials and final system approval have to be carried out during this cruise.

Work at sea

Calibration work will be done during the transit from Las Palmas de Gran Canarias to Bremerhaven. On the transit from Las Palmas to the first testing area, the Ampére Seamount, the different operation modes and the updates of the operation software will be analyzed. The steep slopes and large depth differences of Ampére Seamount are generally challenging for the bottom detector of sonar systems. As this seamount was surveyed several times before, a comprehensive dataset exists for depth comparisons.

The new version of On-line Mean sound velocity option will be tested and approved.

On the transit from Ampére Seamount to the second testing area in Bay of Biscay, the 48 hour stability test will be performed.

In Bay of Biscay are several areas adequate for the calibration of system parameters and for execution of quality tests. These areas have also been measured during previous cruises. The existing bathymetric data will be used for a quality control of the data recorded with the DS III. The main quality test, the so called ‘patch test’, will be executed in a flat area with mean depth of ca. 4400 meter. The area will be surveyed in overlapping and crossing profiles that allows the computation of statistical values.

On transit from Bay of Biscay to Bremerhaven, the ship will reach the continental shelf. Due to the shallow waters and resulting short signal travel times, some system parameters like time latency can be approved and uncertainties or possible errors easily be detected.

Data management

Since data are recorded for test purposes of the system, they will be archived and published in PANGAEA network after being analysed.

3.6 TEILNEHMENDE INSTITUTE/ PARTICIPTING INSTITUTIONS

Institution	Adresse/Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven/Germany
Atlas Hydrographic	Atlas Hydrographic Sebaldsbrücker Heerstrasse 235 28308 Bremen/Germany
CIRES	Cooperative Institute for Research in Environmental Sciences (CIRES) University of Colorado at Boulder 216 UCB, Boulder, CO 80309-0216/USA
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg/Germany
GEOMAR	GEOMAR Helmholtz Centre for Ocean Research Kiel Wischhofstr. 1-3 D-24148 Kiel/Germany
KIT	Karlsruhe Institute of Technology Kaiserstraße12 76131Karlsruhe/Germany
NOAA	NOAA/ESRL/PSD 325 Broadway Boulder, CO 80305-3328/USA
PolE	Laboratory for Polar Ecology (*PolE*) rue du Fodia 18 B-1367 Ramillies/Belgium
RFL	Reederei F. Laeisz Bremerhaven (GmbH) Brückenstr. 25 27568 Bremerhaven /Germany
TROPOS Leipzig	Leibniz-Institut für Troposphärenforschung e.V. Permoserstraße 15 D-04318 Leipzig/Germany
Uni Leipzig	Universität Leipzig P.O. Box 100920 D-04009 Leipzig/Germany
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3.7 FAHRTTEILNEHMER/ CRUISE PARTICIPANTS

	Name/ Last Name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
1.	Bertleff	Marco	KIT	Physicist
2.	Bley	Sebastian	TROPOS	Meteorologist
3.	Blomquist	Byron	NOAA, Affiliate at CIRES	Atmospheric Chemist
4.	Deneke	Hartwig	TROPOS	Meteorologist
5.	Dorschel	Boris	AWI	Geologist
6.	Ewert	Jörn	ATLAS Hydrographic	Engineer
7.	Foth	Andreas	Uni Leipzig	Meteorologist
8.	Fuchs	Susanne	TROPOS	Chemist
9.	Goffette	Quentin	PolE	Biologist
10.	Hempelt	Julia	DWD	Technician, meteorology
11.	Jensen	Laura	AWI	Geodesist
12.	Jonas	Walther	TROPOS	Meteorologist
13.	Klappenbach	Friedrich	KIT	
14.	Klappenbach	Friedrich	KIT	Physicist
15.	Kostinek	Julian	KIT	Physicist
16.	Krieten	G.	AWI	Engineer
17.	Krocker	Ralf	AWI	Geodesist
18.	Lafontaine	René-Marie	PolE	Biologist
19.	Merkel	Maik	TROPOS	Meteorologist
20.	Miller	Max	DWD	Meteorologist
21.	Moran	Ken	NOAA, Affiliate at CIRES	Electrical Engineer
22.	N.N		PolE	
23.	NN		AWI	
24.	NN		TROPOS	
25.	NN		TROPOS	
26.	NN		TPROPOS	

	Name/ Last Name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**
27.	NN		TPROPOS	
28.	NN		TROPOS	
29.	NN		TROPOS	
30.	NN		AWI	
31.	NN		AWI	
32.	Pilch Kedzierki	Robin	GEOMAR	Climate Physicist
33.	Rogenhagen	Johannes	RFL	Geophysicist
34.	Wang	Wuke	GEOMAR	Meteorologist
35.	Wintersteller	Paul	MARUM	Geologist

3.8 SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Pahl, Uwe	Master
Spielke, Steffen	1.Offc.
Ziemann, Olaf	Ch.Eng.
Lauber, Felix	2.Offc.
NN	2.Offc.
Hering, Igor	2.Offc.
Spilok, Norbert	Doctor
Fröb, Martin	R.Offc.
Kotnik, Herbert	2.Eng.
Schnürch, Helmut	2.Eng.
Westphal, Henning	2.Eng.
Brehme, Andreas	Elec.Tech.
Ganter, Armin	Electron.
Dimmler, Werner	Electron.
Winter, Andreas	Electron.
Feiertag, Thomas	Electron.
Schröter, Rene	Boatsw.
Neisner,Winfried	Carpenter
NN	A.B.
Clasen, Nils	A.B.
Burzan, Gerd-Ekkehard	A.B.
Schröder, Norbert	A.B.
Moser, Siegfried	A.B.
Hartwig-L., Andreas	A.B.
Kretzschmar, Uwe	A.B.
Kreis, Reinhard	A.B.
Gladow, Lothar	A.B.
Beth, Detlef	Storekeep.
Plehn, Markus	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Dinse, Horst	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy,Mario	Cooksmate

Name	Rank
Völske, Thomas	Cooksmate
NN	1.Stwd.
Hennig, Christina	Stwdss/KS
Streit, Christina	2.Steward
Hischke, Peggy	2.Stwdess
Wartenberg, Irina	2.Stwdess
Hu, Guo Yong	2.Steward
Chen, Quan Lun	2.Steward
Ruan, Hui Guang	Laundrym.